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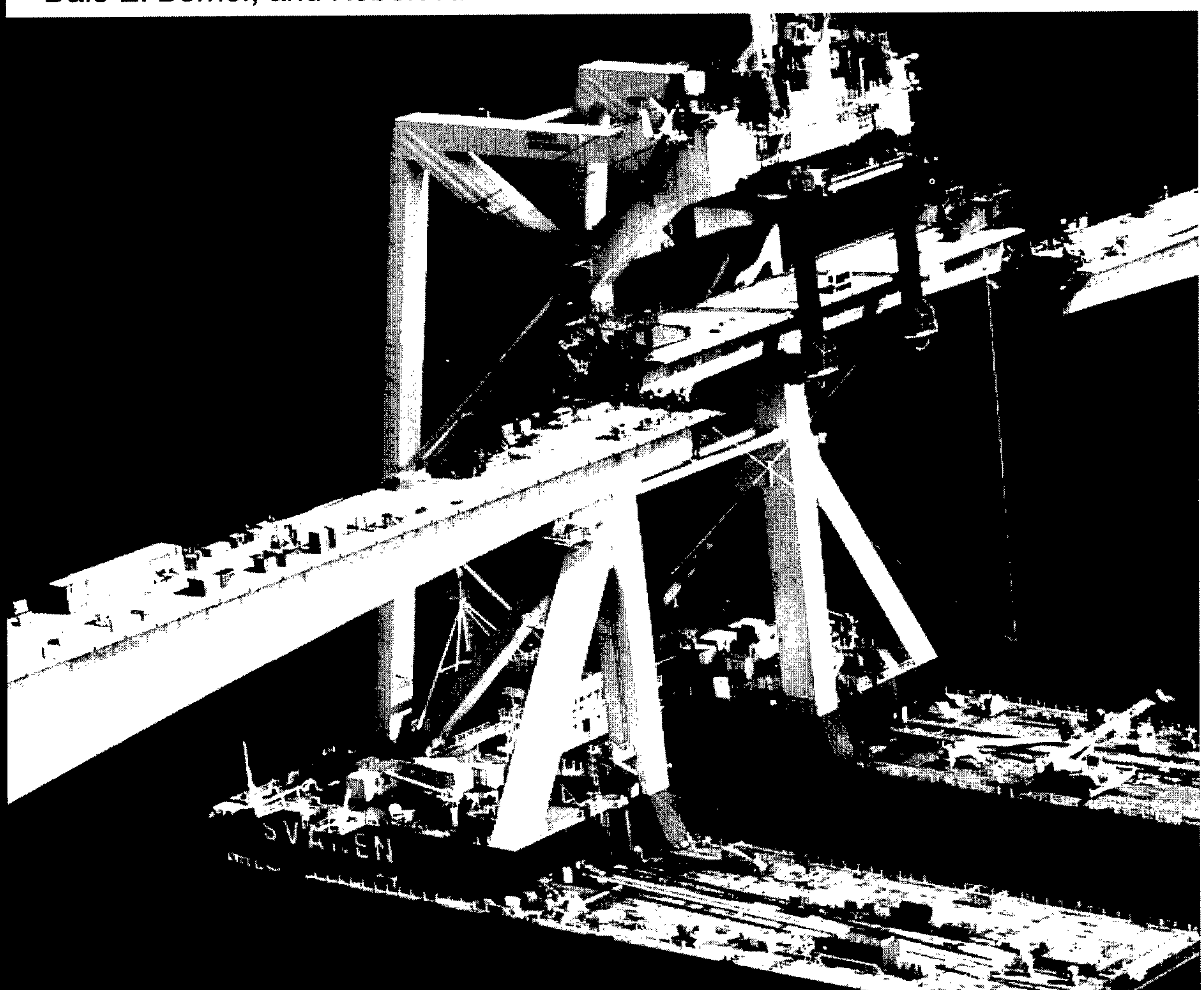
Assessment of Heavy-Lift Equipment for In-the-Wet Construction of Navigation Structures

Ben C. Gerwick, Sam X. Yao,
Dale E. Berner, and Robert R. Bittner

November 2000



Geotechnical and Structures Laboratory

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Innovations for Navigation
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Assessment of Heavy-Lift Equipment for In-the-Wet Construction of Navigation Structures

by Ben C. Gerwick, Sam X. Yao, Dale E. Berner, and Robert R. Bittner

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Final report

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Preface

The work described in this report was authorized by Headquarters, U.S. Army Corps of Engineers (HQUSACE), as part of the Innovations for Navigation Projects (INP) Research Program. The work was performed under Work Unit 33150, "Equipment Requirements for Lift-In Construction of Navigation Structures," managed at the U.S. Army Engineer Research and Development Center (ERDC), Geotechnical and Structures Laboratory (GSL).

Dr. Tony C. Liu was the INP Coordinator at the Directorate of Research and Development, HQUSACE; Research Area Manager was Mr. Barry Holliday, HQUSACE; and Program Monitor was Mr. Bruce Riley, HQUSACE. Mr. William H. McAnally of the U.S. Army Engineer Research and Development Center (ERDC) Coastal and Hydraulics Laboratory was the Lead Technical Director for Navigation Systems; Dr. Stanley C. Woodson, ERDC GSL, was the INP Program Manager.

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At the time of publication of this report, Dr. James R. Houston was Director of ERDC, and COL James S. Weller, EN, was Commander.

1 Introduction

Background

In recent years, the U.S. Army Corps of Engineers has launched major developments in underwater construction of locks and dams, using the so-called "in-the-wet" or "offsite prefabrication" construction method. This innovative method uses precast concrete modules as the in situ form into which tremie concrete or other infill material is placed directly without use of a cofferdam. The tremie concrete is designed to work in composite action with the precast concrete modules. Numerous in-depth investigations have been conducted by several Corps districts and their consultants to evaluate the feasibility of the in-the-wet method at various potential sites of U.S. inland waterways. These studies have shown that the innovative construction method can provide substantial benefits in cost, construction time, risk reduction, and facility utilization, while minimizing disruption to river traffic and reducing environmental impact.

In terms of the construction methods used to transport and install the precast concrete modules, in-the-wet construction methods can be generally categorized as lift-in or float-in. Float-in construction entails transportation of prefabricated large concrete modules from their casting yard or outfitting site to the project site by flotation and/or by means of external buoyancy tanks. Precast modules for float-in construction are usually thin-shelled floating structures with internal ballasting compartments. Once the float-in modules are precisely positioned over the site with a suitable guide system, they are lowered to the prepared foundation by means of ballasting.

In lift-in construction, the prefabricated concrete modules themselves do not float. Towed barges and/or lift equipment must be used to transfer the precast modules from their casting yard to the project site. Installation of the lift-in modules generally requires large floating cranes to position them within an acceptable tolerance. Auxiliary guiding systems, such as mooring systems, tensioned guidelines, and guide horns, are often used to assist the positioning.

Selection of the installation method and equipment for precast modules is an important design decision. Each installation method and equipment has unique implications with regard to project cost, construction schedules, river traffic, towing and mooring system, installation stability, positioning accuracy, and level of risks during construction. In many ways, the installation method will at least in part determine the size and configuration of precast concrete modules, the

foundation treatment, and construction sequence and schedule. In general, a thorough evaluation should be made in the early stage of design to determine the impact of the installation method and equipment on construction cost and schedule. The choice of installation method and equipment will affect the structural concept and layout, fabrication of precast components, and construction logistics.

The float-in construction method is based on prefabricating independent floating structures that can be towed to the project site through waterways. This method has several advantages. First, it avoids heavy-lift equipment, which often represents a substantial portion of the project cost. Second, float-in segments can be made as large as practical without any concern for equipment capacity. Large precast segments generally lead to fewer underwater joints and lower overall construction cost.

However, there are also disadvantages with float-in construction. The float-in modules usually have a bottom slab that can complicate their "tie-in" to preinstalled foundation. Installation of the modules requires carefully controlled ballasting and deballasting operations. In some cases, river draft can become a significant constructibility issue.

Finally, this method requires a launching system for loading the float-in components from the casting yard to the river. This may sometimes become a significant cost factor. The float-in method can often be used effectively where the environmental constraints are not too severe, the shapes of precast modules are favorable, and large precast modules are required.

The lift-in method allows for construction of lift-in segments without a bottom slab and avoids the launching and ballasting issues. River draft is not a significant problem with the method, because large precast segments often increase the barge draft by only a few feet. Construction of lift-in segments is substantially simplified since the segments are not required to float over water. However, the segments must be designed to withstand all the loads during transportation and installation at the site. In general, the lift-in method is usually efficient when a large number of precast segments have to be installed onsite or where environmental conditions impose restrictions on the effective use of the float-in method.

The lift-in method can be further divided into two broad categories: light lift-in and heavy lift-in. The light lift-in method typically makes use of existing equipment capable of lifting precast concrete modules up to 500 tons. It is well suited for small jobs and retrofit work. The heavy lift-in method uses large lift equipment capable of lifting over 500 tons weight. In general, lift-in construction is justified when a larger number of precast concrete segments must be installed.

The lift-in method for lock and dam construction is basically an extension of the existing marine construction methods used for construction of offshore structures and bridges. However, the construction methods and equipment used in offshore applications are subjected to various constraints of the inland waterways, such as bridge headroom clearance and draft requirement. As the lift-in method is

being developed from a concept into detailed design and construction planning, it has become evident that an in-depth investigation into the past and current use of these technologies has significant value to the success of their applications to the construction of locks and dams. This report focuses on the technical and economical aspects of floating crane equipment used to lift and position large prefabricated elements in the inland waterways.

Objective

The objectives of this report are as follows:

a. To examine the basic requirements for equipment used in the lift-in construction.

b. To identify and determine the availability, production rates, and cost of equipment for lifting, transporting, and installing large precast modules.

c. To investigate the advantages and limitations of various lift equipment suitable for inland waterway construction.

Scope

This report is divided into two parts. The first part (Chapter 2) describes the general requirements and evaluation criteria for heavy-lift equipment used in transportation and installation of large prefabricated modules in the U.S. inland waterways.

The second part (Chapter 3) investigates eight general categories of heavy-lift equipment:

a. Revolving lattice boom crane, with ringer attachment or permanently fixed tub, on a floating barge.

b. Shear-leg ("A-frame" type) crane barge.

c. Offshore crane barge.

d. Jack-up crane barge.

e. Catamaran barge with lifting beams.

f. Catamaran barge with linear jacks/rods.

g. Float-over construction method and equipment.

h. Synchronized multiple lifting systems (Versatruss).

Each type of equipment is evaluated as to determine its cost, production rate, suitability, and availability for inland waterway construction.

2 Overview of Lift-in Construction

The lift-in method of constructing navigation structures uses conventional marine equipment and techniques. It entails several important construction stages. The first stage is prefabrication of strong and durable precast concrete modules that assume the exterior shape of the final structure (e.g., locks, approach walls, still basins, tainter gate sills). The modules are fabricated in a construction basin on the riverbank or on barges. Then, the modules are outfitted with the permanent attachment (e.g., bulkheads and tainter gates) and the necessary construction attachments (e.g., lift frames and hydraulic jack).

The second stage is to transport and install the prefabricated modules. Transportation of the modules to the project site is typically carried out by transport barges and floating crane barges. In the precasting yard, these precast modules have to be positioned within the reach of a floating crane, or transferred onto a barge through such means as a skidway or a jetty. The crane barge or transport barge is usually moved by towboats. Once at the site, the barge will typically be held in position with a mooring system consisting of winches, mooring lines, and anchors. To be able to accurately position the modules, the mooring system must be rigid enough to hold the crane barge in a relatively fixed position against strong wind and currents. A system of mooring winches will provide the force to control the barge location. If the water depth is relatively shallow, spud piles may be used for holding the barge in position.

When a crane barge is working at a job site, the moorings are laid out in a way that allows the barge to reorient and relocate in order for the crane to reach as many locations of the site as possible. Although there are exceptions, as a general rule, mooring lines should never cross during a reorientation. Crossing of mooring lines prevents retrieval of the underneath line, and leads to erratic reactions from the lines (as the load in one line changes its catenary and affects the other). Worst of all, this situation increases the possibility of one line snagging the anchor of the other line.

Installation of the prefabricated modules is a critical operation in the construction process. Figures 1-4 illustrate lift-in placement of various structural components over water by crane barges. The most important requirements for the installation operations are horizontal and vertical alignment of each precast module relative to the axes of the structure and to adjacent segments. Thus, the lift

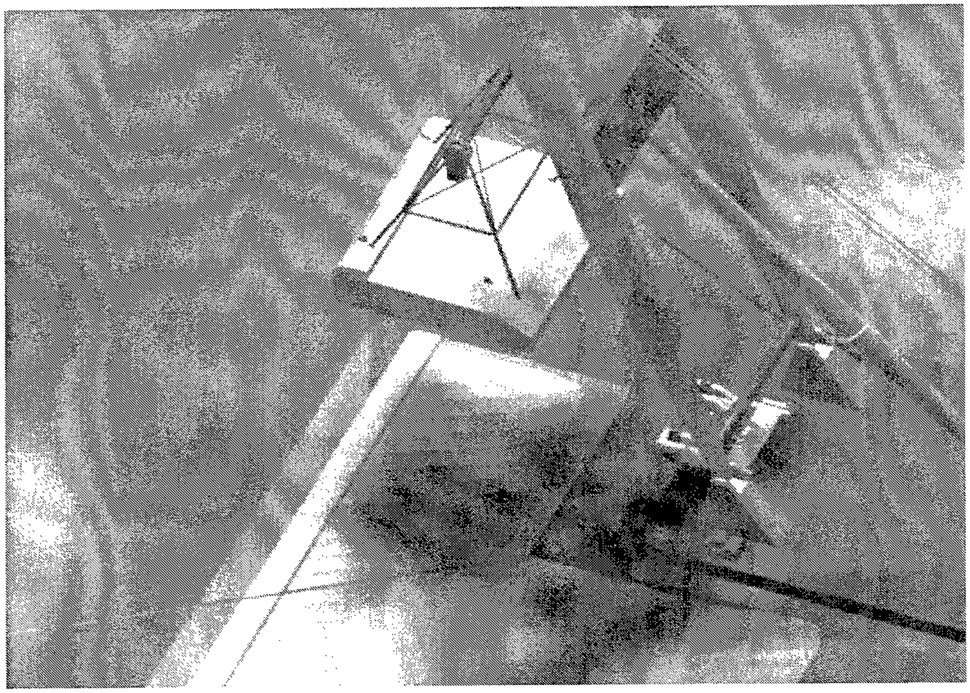


Figure 1. Lift-in placement of a wicket gate sill

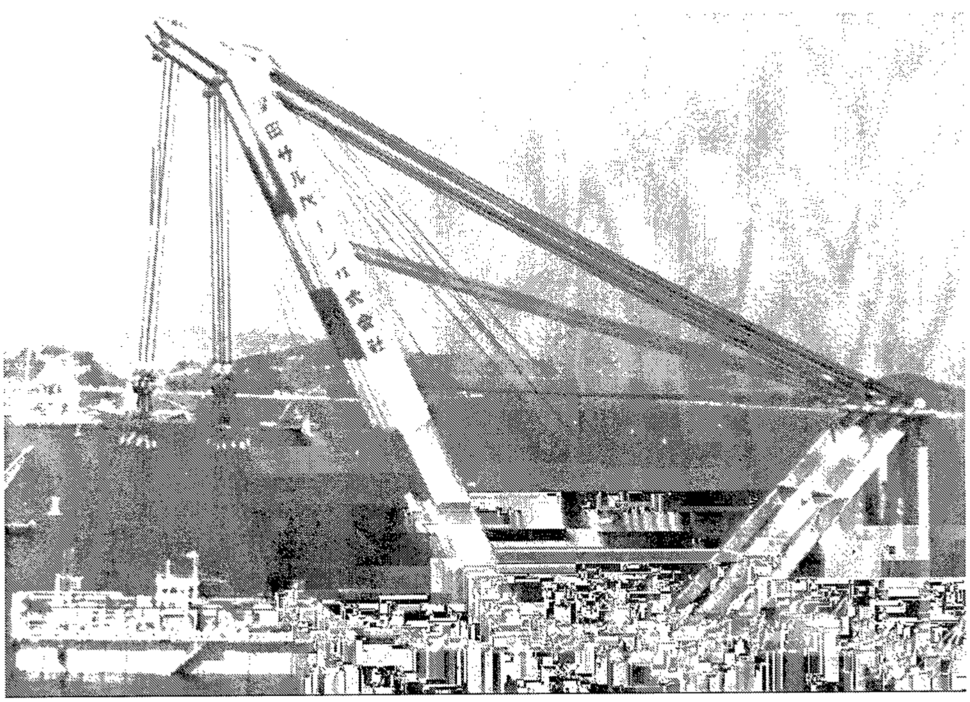


Figure 2. Lift-in placement of a bridge caisson

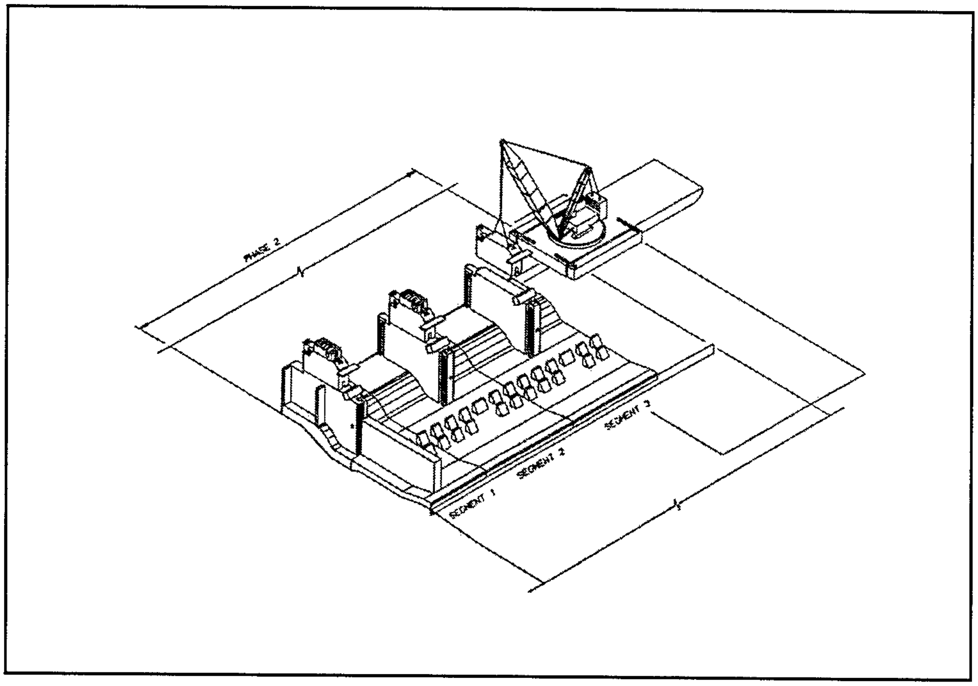


Figure 3. Lift-in placement of a segment of tainter gate pier

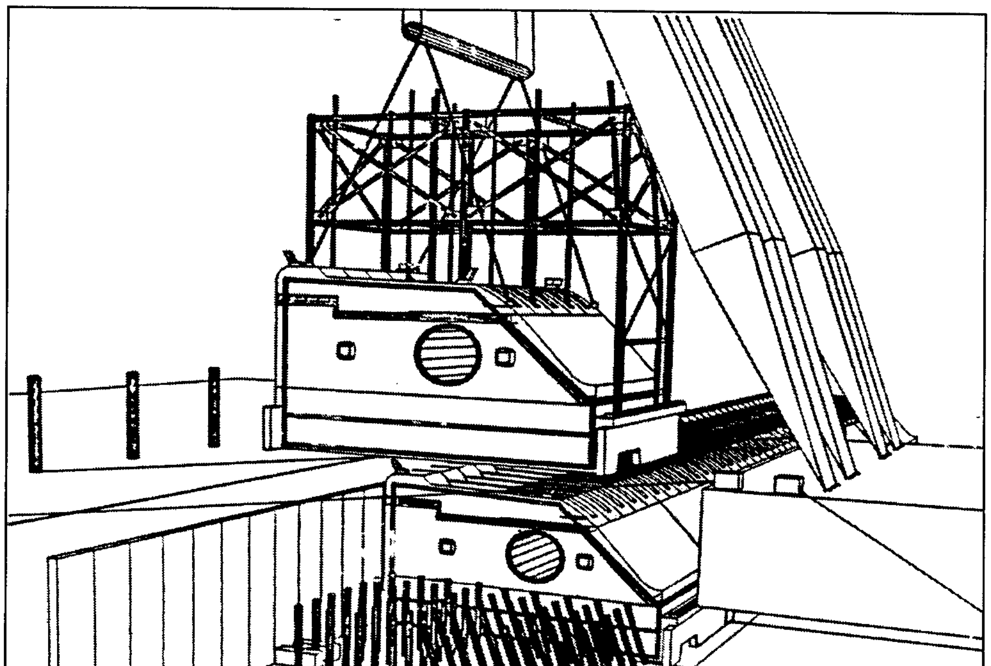


Figure 4. Lift-in placement of dam sill

equipment should be able to position very large precast segments above and below water in a fully controlled manner. Positioning of large precast components entails intensive onsite coordination of several operations, including surveying, adjustments in mooring systems and ballast systems, operations of crane and guide systems, barge maneuvering and, at times, diving inspection.

Survey tasks carried out during the placement operations will require a high degree of accuracy for vertical and horizontal positioning of the precast shells. It is common to employ multiple survey systems such as the differential global positioning system (DGPS), lasers and total station, and underwater sonic sensors. In general, land-based survey methods are the primary tools for monitoring the placement, while underwater sonic devices and divers are supplementary methods used to cross-check the other survey readings.

During placement of the precast shells, the crane barge and survey boats are usually positioned with real-time kinematic DGPS, and/or laser, EDM, and theodolite. The vessel usually needs to be positioned within a 1-ft (0.3-m) tolerance.

For horizontal alignment, a fixed-beam laser system may be used to provide direct guidance to the crane operator. Inclinometers may be mounted to a spotting tower to check leveling of the prefabricated module during the placement and to monitor list and trim. Spotter hydraulic jacks may be positioned between the hull of the crane barge and the lifting frame to correct the fine positioning and inclination of the prefabricated module.

For vertical control of the precast shells that are set completely below water, land-based survey instruments should be used to spot targets fixed to a spotting tower on the modules that extends above the water. Simultaneously, a multifrequency, narrow-beam transducer echo sounder may also be used to detect the depth to the riverbed. In the recent construction of the Northumberland Crossing, the lift-in placement of 7,000-ton precast concrete caissons by a catamaran achieved a positioning tolerance of 1 in. in plan. The placement of the 7,300-ton bridge caisson foundations of the Great Belt Link-West Bridge, using a large crane barge, also obtained similar tolerances.

A complete lifting operation can create a number of load cases. The designer should in principle consider the entire lifting sequence step by step and identify the most critical load case for each structural member. There are both static and dynamic forces to consider. The static forces include the actual load itself, which, if not weighted, must be computed to include the design weight plus adequate allowances for overtolerance in member dimensions, welds, padeyes, and any supplement attachments. Static lifting loads must also include the slings, shackles, spreader beams, and lift frames. Lifting and setting heavy objects involves motion and, hence, dynamic loading and impact effects. The dynamic loads are those due to both vertical and horizontal accelerations during lifting and setting weights, and during swing. American Petroleum Institute (API) document RP2A, Section 2.4, "Installation Forces," contains specific recommendations to ensure safe lifting of heavy loads over water.

Vertical components of lifting forces may include the favorable effects of buoyancy where the modules are fully or partially submerged in water. Advantage can be taken of the buoyancy effects in lifting very heavy loads. For example, 66 prefabricated concrete piers of the Oosterschelde Storm Surge Barrier, Netherlands, were lifted and installed by a catamaran barge. Figure 5 shows the catamaran *Ostrea* (rated at 12,000-ton lift capacity) carrying a 24,000-ton concrete pier from its fabrication yard to the project site. A major portion of the pier was submerged in water, which provided enough buoyancy to counterbalance the excess weight of the pier. In taking advantage of buoyancy to carry submerged objects, precaution should be taken to consider the fact that the submerged objects will pick up an added hydrodynamic mass component. The added mass can add considerable force to the crane boom when the submerged object has large horizontal surface area and the crane barge experiences significant list and trim, as illustrated in Figure 6.

One of the critical components is the connection of the lifting gear to the lift-in module. The gravity loads from the segment have to be picked up by the lifting gear. Similarly, the modules must be strong enough to transfer the loads to the lift points. The general rule is that the attachment points of the lifting gear to the modules should have an elastic capacity equal to the breaking strength of the wire lines or rods. This rule is to ensure that any failure will occur only in the slings, not the structure. Typically, the maximum negative moments occur at the attachment points. To prevent excessive cracking in the segment, additional strengthening and reinforcement (confinement) around the embedment of lift device (e.g., padeyes) are often provided. For odd-shaped precast segments, torsion must also be considered.

Uncertainties with respect to internal force distribution and possible accident loads require a high safety margin. API RP2A recommends that a minimum load factor of 1.35 be applied to the calculated static loads for lifts to be made in the open sea. This must then be multiplied by the material factor of 2.0. Thus, it is somewhat less than the conventional wire-rope rigging design, for which a factor of 4 to 5 is normally applied to the minimum guaranteed breaking strength to determine the safe calculated static load. The U.S. Occupational Safety and Health Administration requires a safety factor of 5 on ultimate strength on all lifting gear (wire rope shackles and padeyes), whereas the American National Standards Institute requires a factor of 3 on yield strength. The two codes are approximately equivalent. These conservative safety factors should also be applied to the padeyes and other internal members connecting directly to the padeyes. All other structures are designed using a minimum load factor of 1.35.

Structural members, padeyes, and other attachments for lifting relatively less heavy loads in harbor and inland waterways are usually designed on the basis of allowable (elastic) stresses, using an approximate impact factor of 2.0. No increase in the allowable stress is permitted due to short-term loading. The allowance for impact by a factor of 2.0 is also applicable to lifting inserts in concrete. In addition, all critical structural connections and primary members should be designed to have adequate ductility to ensure structural integrity during lifting, even if temporary or local overloads occur.

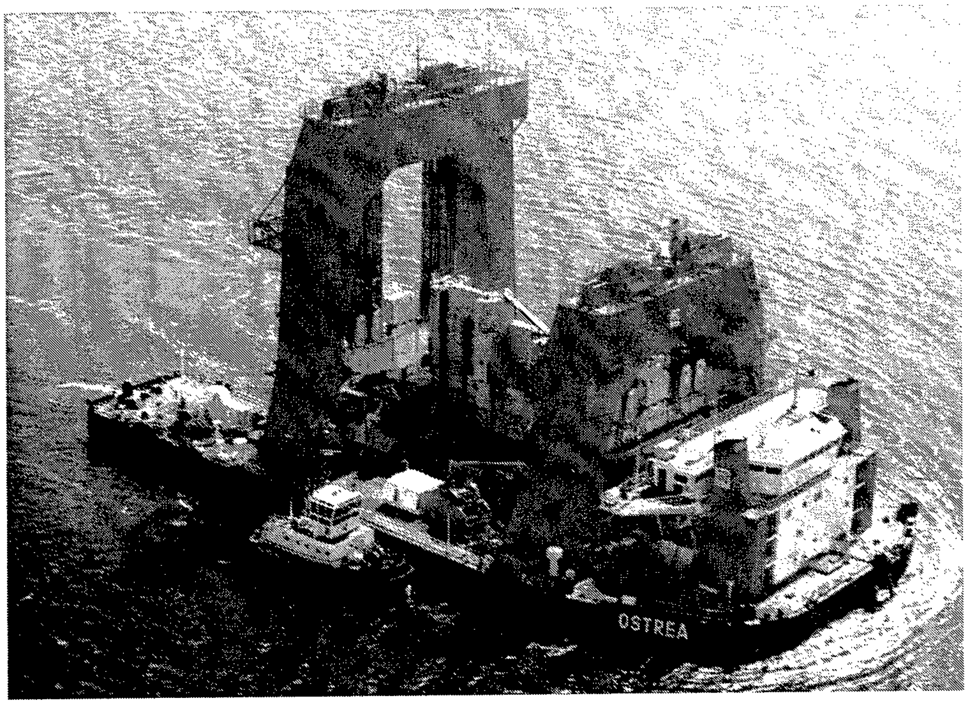


Figure 5. Catamaran carrying a 24,000-ton pier to the Oosterschelde storm surge barrier site

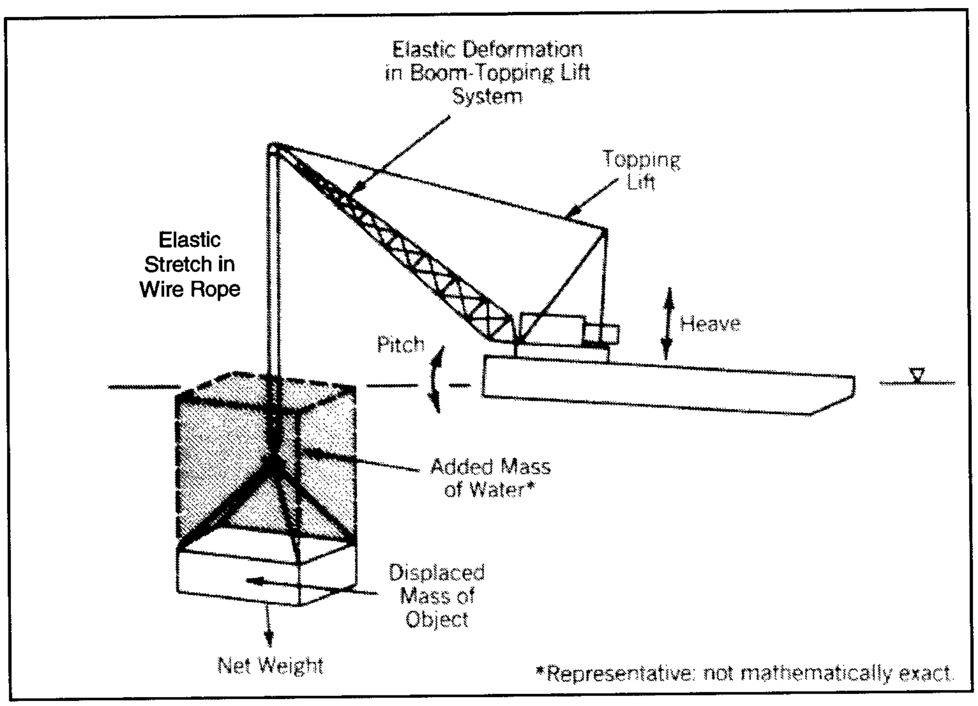


Figure 6. Schepmatic representation of added mass dynamics of lowering loads below water

When suspended, the lift will assume a position such that the center of gravity of the load and the centroid of all upward forces are in static equilibrium. These relative positions should be taken into account in determining the inclination of the slings. The force in the sling is the resultant of the horizontal and vertical forces at the padeyes. Due to swinging of the load while in the air, the load will not be uniformly distributed on all four slings. This nonuniform distribution must be considered in sizing the slings and their fittings. In practice, lifted loads are generally controlled against swinging by use of tag lines.

During picking and setting of the load, the position may vary from the above, due to the horizontal and vertical reactions from the deck of barge as well as those from tag lines and guides. The change in horizontal and vertical forces must be considered in determining the forces and angles of application on padeyes and hooks.

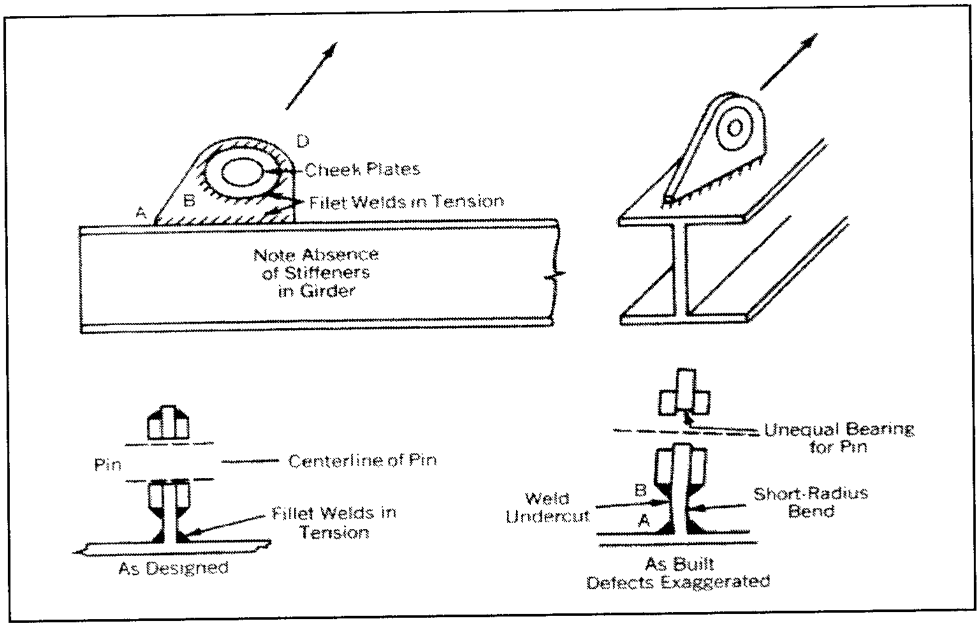
The design of padeyes requires special attention and detailing. Figure 7 shows examples of correct and incorrect design details of padeyes. Padeye plates should be oriented in such a direction that the possibility for out-of-plane loading of the padeye plate and on the shackle is minimized. Wherever possible, the load from the padeye to the girder should be transmitted in shear rather than tension. The use of cheek plates should be avoided, if possible. The distance from girder to pin should be at least six-plate thickness. Where cheek plates are necessary, they should be welded to the main load-carrying plates with bevel welds, sufficient for an even transfer of stresses, on the inside and with fillet welds on the outside. If connection between padeyes and structure cannot be transmitted by shear, then full-penetration welds should be employed.

Transverse welds perpendicular to the principal tension, where the member is subjected to impact, is prohibited by some national codes. If they are used, the details, welding procedures, and nondestructive testing used to verify them must be such as to ensure full development of ultimate strength and ductility. Fillet welds are especially dangerous under impact tension, whereas full-penetration welds may be safely employed.

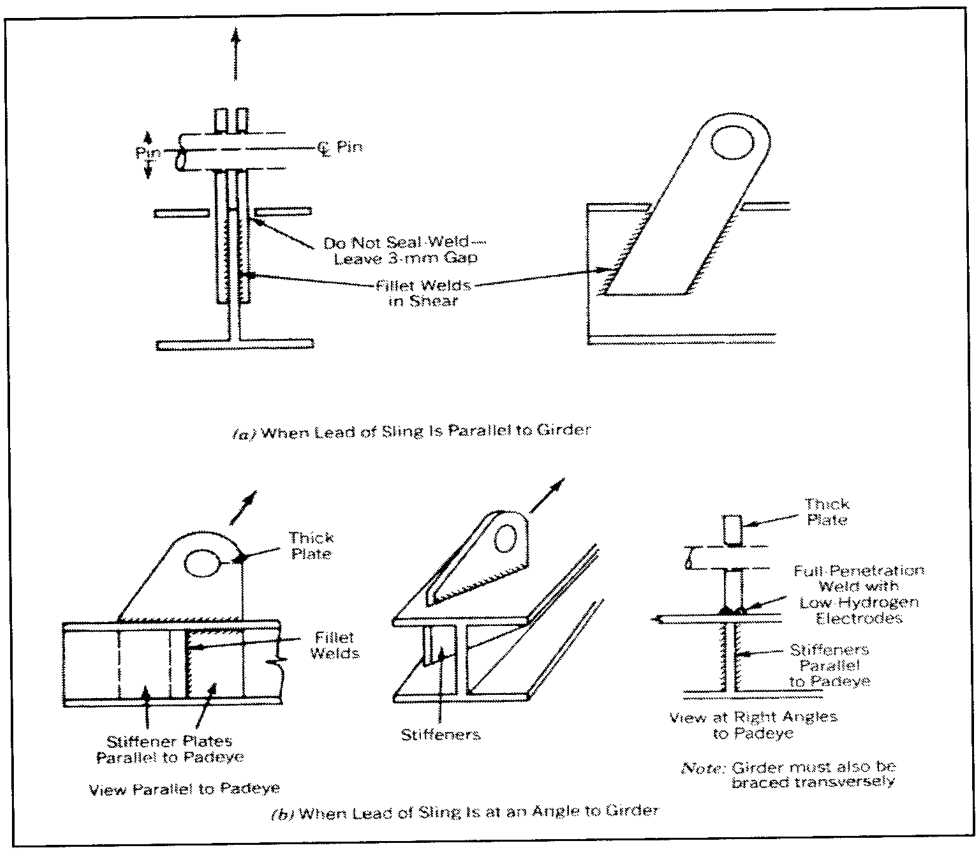
Special attention should be paid to the fact that the fabrication tolerances and variations in sling lengths can redistribute the actual forces, resulting in overstress of some individual members. The variation in sling length should not exceed ±0.5 percent of the sling length or 75 mm (3 in.).

Many modules are designed to withstand the vertical quasi-static forces imposed in lifting the prefabrication yard, where bridge cranes or skids are often employed. Over water, the lead of the slings is usually inclined in two planes. Although the padeyes are usually adequately designed for vertical and horizontal loads, the structural components to which the padeyes connect must also be able to transfer the total vertical and horizontal forces back into the module.

With regard to underwater installation characteristics, there are two types of precast modules for navigation structures. The first type of precast modules is generally stocky in size and has adequate depth. Typical examples are tainter gate



a. Incorrect and dangerous padeye details



b. Safe padeye details

Figure 7. Examples of incorrect and correct padeye details

sill segments and lock wall segments (as shown in Figures 4 and 8, respectively). These segments can be designed as either lift-in or float-in modules. The second type of the modules has the shape of a flat slab—relatively large in plan dimensions and shallow in depth. Typical examples of such modules are stilling basin segments, as shown in Figure 9.

The second type of precast modules does not generally have adequate depth as a floating structure. While these flat plate modules are being lowered into the water, they could experience substantial fluttering (due to vortex shedding) and distortion (due to their flexibility). In addition, the module can be subjected to very high bending stresses near the picking points of the lift equipment due to its own weight. Therefore, the flat plate modules are usually fitted with a structural steel frame to facilitate the lift-in operation. The steel frame is usually secured to the top of the module before launching (Figure 4) and can serve multiple purposes. First, it distributes the lift force from the crane hoist to the concrete segment through many picking points, thereby reducing bending moments in the segment. Second, the frame serves as a spotting tower for accurate positioning of the segment underwater. Finally, it may serve as a guide frame for lowering tremie pipes into the segment at specific locations so that underwater concrete can be filled within the precast modules. Thus, the steel frame is also referred to as the tremie support frame.

Installation of these precast segments is largely independent of water level, but is somewhat constrained by riverflow velocity, with an upper limit of 1.8 to 2 m/sec (6 to 7 fps), based on prior experience.

Once the precast module is secured on the riverbed, underwater concrete will typically be placed to fill the precast segments through tremie pipes. The tremie concrete is frequently intended to fully bond to the precast concrete shell to form a monolithic structure. Since the precast modules are used as the in situ form for placement of underwater concrete, neither cofferdam nor conventional formwork is needed in the construction.

Example Projects

In principle, lift-in construction has proven to be a viable and effective marine construction method. There have been many examples of major marine construction projects in which the lift-in method provided cost-effective solutions. Some notable projects are listed below:

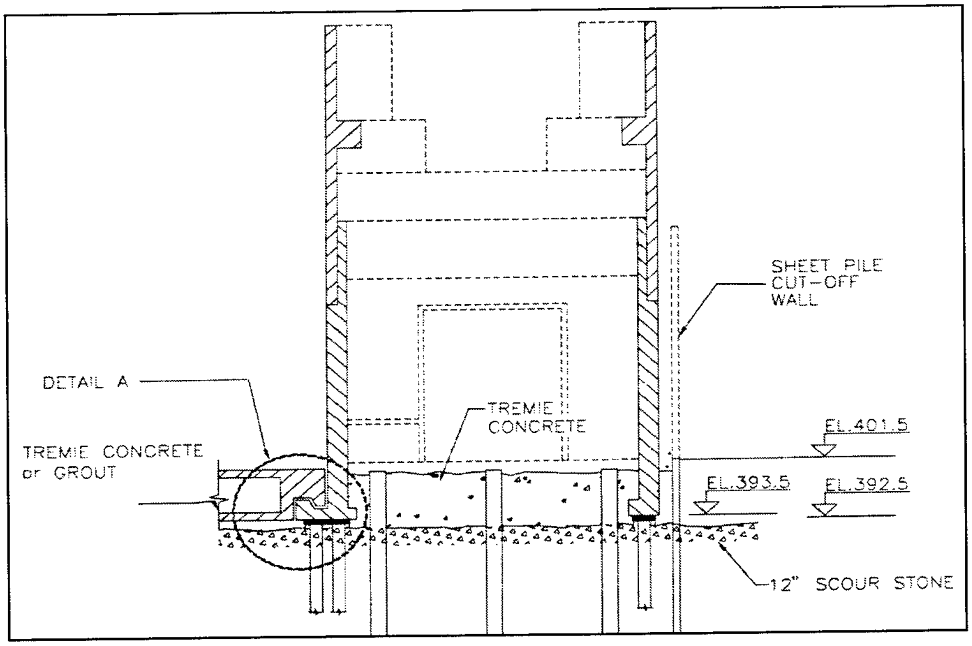
a. Three U.S. Navy Submarine Dry Docks, San Francisco Naval Shipyard.

b. Richmond-San Rafael Bridge substructure (66 piers), San Francisco Bay.

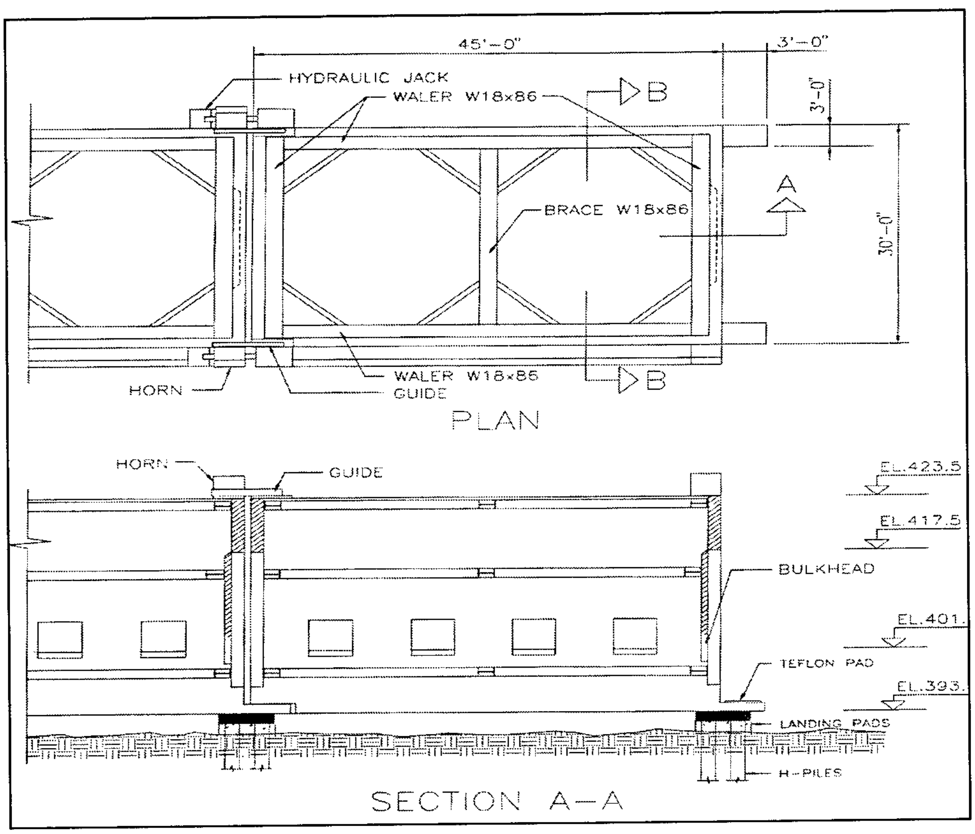
c. San Mateo-Hayward Bridge substructure (20 piers), San Francisco Bay.

d. Columbia River bridge substructure (30 piers), Astoria, OR.

e. Britainia offshore platform (10,700-ton integrated deck), North Sea.

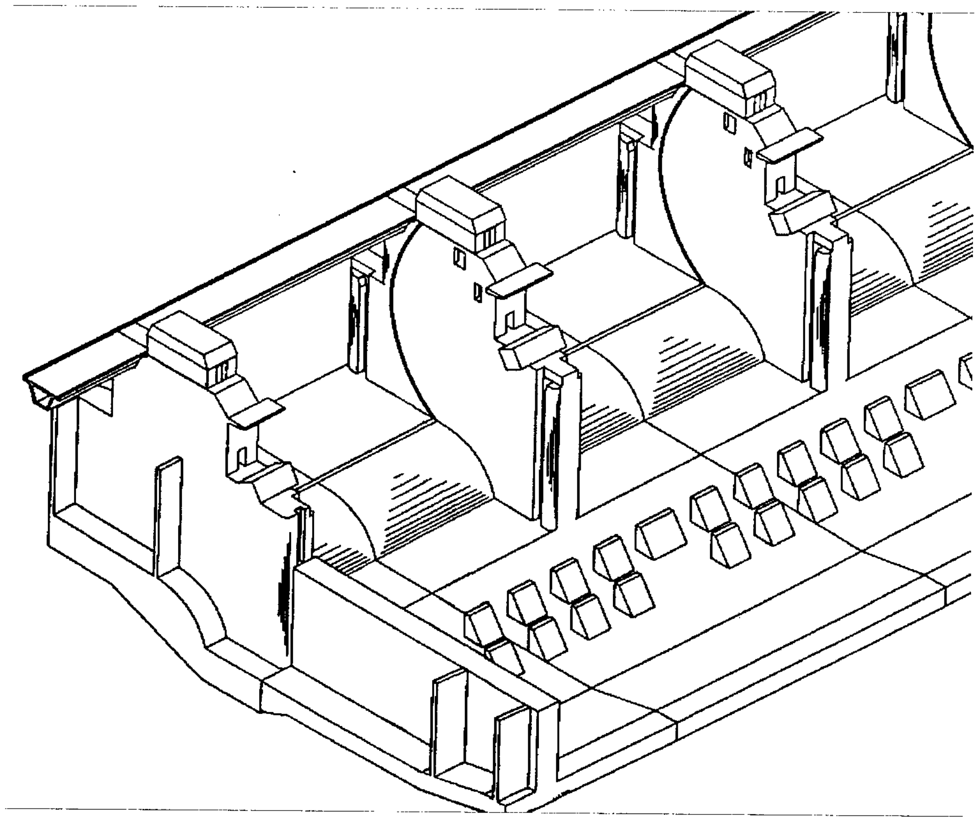


a. Precast lock wall module

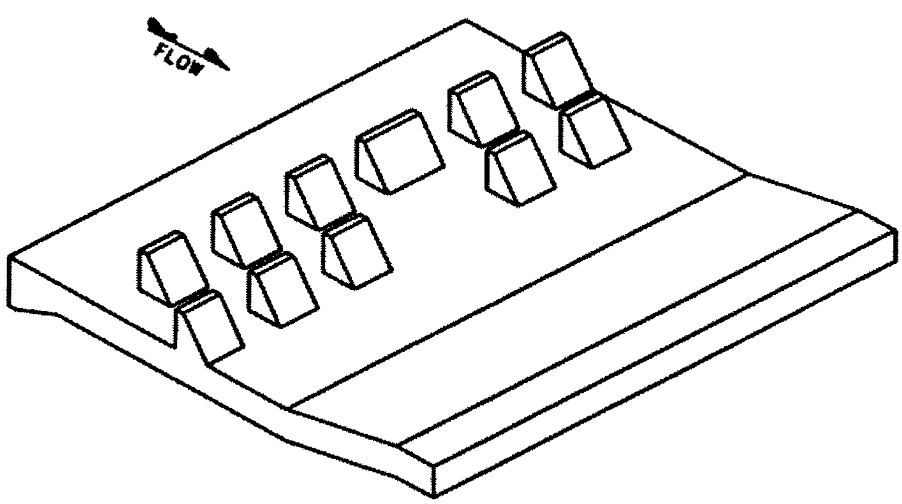


b. Adjacent module

Figure 8. Layout of a precast lock wall module and the connection with an adjacent module



a. Portion of a tainter gate structure



b. Precast concrete stilling basin segment

Figure 9. Examples of modules for stilling basin segments

f. Oosterschelde Storm Surge Barrier (66 piers), Netherlands.

g. Second Severn Bridge (37 caissons), England.

h. Tagus River Bridge (150 bridge girders), Portugal.

i. Great Belt Link, Western Bridge substructure (330 piers and girders weighing up to 7,000 tons), Denmark.

j. Prince Edward Island Bridge (44 pier bases, 44 pier shafts, 44 main span girders and 43 drop-in girders), Canada.

k. Oresund Bridge substructure (two 20,000-ton caissons), link between Denmark and Sweden.

These projects fully demonstrate the feasibility and economy of lifting and setting very large precast concrete modules underwater by means of heavy-lift equipment. Two examples are discussed in further detail below to illustrate the scale and procedures of lift-in construction.

Second Severn Bridge, England

This 5-km (3-mile)-long bridge rests on 37 precast caisson shells, each filled with tremie concrete. Each precast caisson shell sizes up to 53 m (174 ft) in length and weighs over 2,000 tons.

To transport the precast concrete shells from the onshore fabrication yard to the bridge site, two 1,200-ton Lampson crawler tracked transporters were used to carry the shells to a flat-top barge (see Figure 10). At high tides, the barge took the Lampson transporters and the caisson out into the estuary, near the Transi-lift cranes on the prepositioned four-legged jack-up barge.

To place the caisson shell in the exact position of the bridge pier foundation, the contractor selected a jack-up barge with two Lampson LTL 1500 Transi-lift cranes. The jack-up barge was strengthened to take the 700-ton uplift from the Lampson cranes' rear-mounted hydraulically operated slewing beams, which provide lateral positioning of the two 67-m (220-ft)-long booms. The beams were pinned to special anchorage on the pontoon deck in place of normal counterweights. Before arrival of the barge and caisson, the front legs of the jack-up barge were spotted on concrete pads cast on the estuary bed and preloaded to the maximum 3,500 tons by water-ballasting the barge. This verified that the estuary bed could support the pontoon and precast unit during the lift-in operation.

Each caisson's location coordinates were determined by a computerized navigation system on the barge. The navigation system guided the barge into position to an accuracy of 0.5 m (1.6 ft) while the caisson was picked up by two Lampson Transi-lift cranes (Figure 11). The caisson was connected to a table-type lift frame slung from the cranes. The adjustable frame was hydraulically preset and pinned to adjust for dimensions of different caissons. The frame's L-shaped

Figure 10. Loading out a caisson to a barge with a crawler transporter

Figure 11. Lift-in placement of bridge caissons with a jack-up barge

legs were pivoted outward to allow it to be lowered over the caisson. Once lowered, the legs were repositioned and pinned vertically to fit into slots cast into the caisson bottom.

The exact location of the jack-up barge was determined by a satellite GPS, which also served as the caisson positioning reference datum. At the turn of the tide, the caisson was lifted off the barge and the barge moved off station. The monitoring data from the survey were fed into the crane controller's central computer. The controller had real-time readings of the actual position of the caisson and boom points, as well as boom point loads. Instructions were radioed to the crane operators as the caisson was lowered by the two cranes in synchronization to 350 mm above the prepared foundation. Any necessary crane adjustment was made before final leveling by remote-controlled 300-ton hydraulic jacks, housed in the base of each lifting frame leg. The jacks acted as temporary anchors to withstand the 270-ton combined lateral wave and tidal current acting on the caisson. The caissons were placed to 50-mm tolerance in all directions.

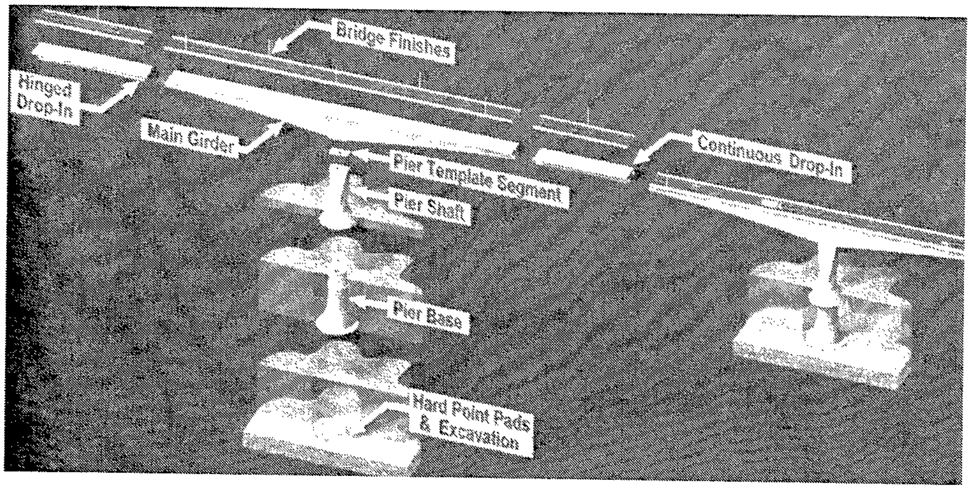
After positioning, preinstalled grout bags around the caisson base were pressure-injected. When the cement grout reached the required strength (usually by the next tide), the frame jacks were released and the load transferred from the crane to the hardened grout bags. Then, the lifting frame was hoisted out of the way and the jack-up barge was relocated to its next caisson location.

Confederation Bridge, Canada

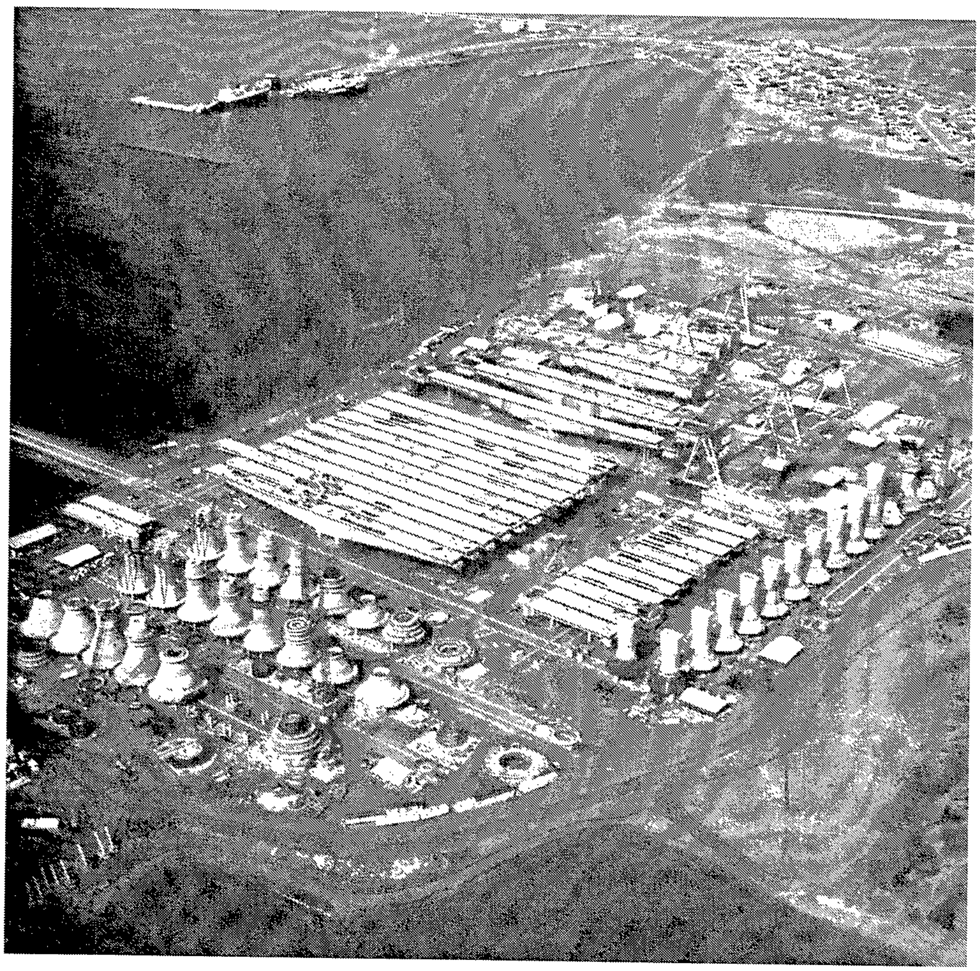
Construction of the Confederation Bridge, or the so-called Prince Edward Island Bridge, over the Northumberland Strait in Canada was a 2-year design-build project. In many ways, the project represents the state of the art in offsite prefabrication, segmental launching, and lift-in construction. The bridge consists of an 11.0-km-long main bridge and 1.9-km-long approach bridges. The overriding concern of the project was the severe and unpredictable weather condition at the bridge site. The winter storms, blizzard, and ice floe across the Northumberland Strait greatly restricted the onsite construction window and made overwater construction very difficult. As a result, the winning design was a prestressed concrete box girder bridge that was entirely prefabricated offsite and segmentally lifted in onsite. The offsite fabrication and lift-in construction required minimum onsite construction and allowed for more effective project control.

All the bridge components were made of prestressed/reinforced high-strength concrete, totaling 478,000 m^3 in volume. Figure 12a shows a set of prebuilt main bridge sections and how those sections fitted together.

All main bridge components were built atop high concrete pillars in a precast yard near the bridge site, as shown in Figure 12b. Between sets of pillars there was a two-track skidway upon which a Huisman sledge would slide. To move a concrete component, a Huisman would travel down the skidway until it was directly under the component (see Figure 13). Jacks on the sledge would raise the



a. Precast components of the main bridge span



b. Prefabrication of the bridge pier segments and the main girders

Figure 12. Construction of the Confederation Bridge

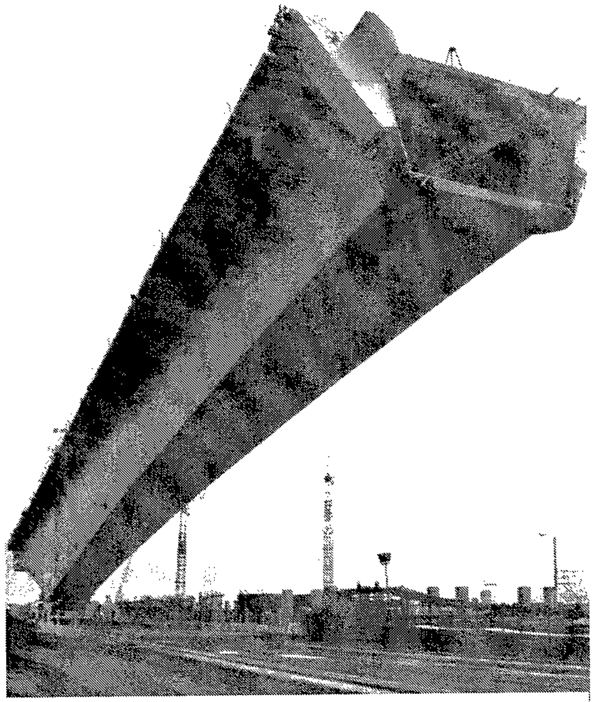


Figure 13. Moving the main girder on a Huisman sledge

component a few centimetres off its supporting pillars. The sledge would then crawl down the track, carrying the component to the next work station or to the storage area. Loading out these precast components was accomplished through a 500-m-long jetty to accommodate for a heavy-lift vessel, the *Svanen.*

Svanen is a catamaran (103 m long, 72 m wide, 102 m tall) that was used to transport and place the main bridge components. The vessel was purchased in Europe and modified to accommodate the heavy lifts for the project. The lift capacity was increased from 7,000 to 8,500 tonnes.

The major marine work involved dredging and placement of precast segments. Figure 14 shows the *Svanen* approaching the jetty to pick up a pier base from atop a Huisman sledge. The *Svanen* then traveled to the bridge site and was anchored firmly into the position with eight preset anchors. After final positioning guided by GPS, the pier base was lowered to set on three pre-set hard points. Picking up and placing of the pier shafts and match-cast templates was similar to that of pier bases, except that the pier shaft was not set directly onto the pier base. The two pieces were held slightly apart by jacks. The narrow space between the components was later filled with grout, creating a solid load-bearing connection.

Lifting and placing the 7,500-tonne main girders required special care. Energy absorbers were used to reduce impact force and to control the lowering of the girders. Figure 15 shows the *Svanen* placing Main Girder 22 at the halfway point across the main bridge.

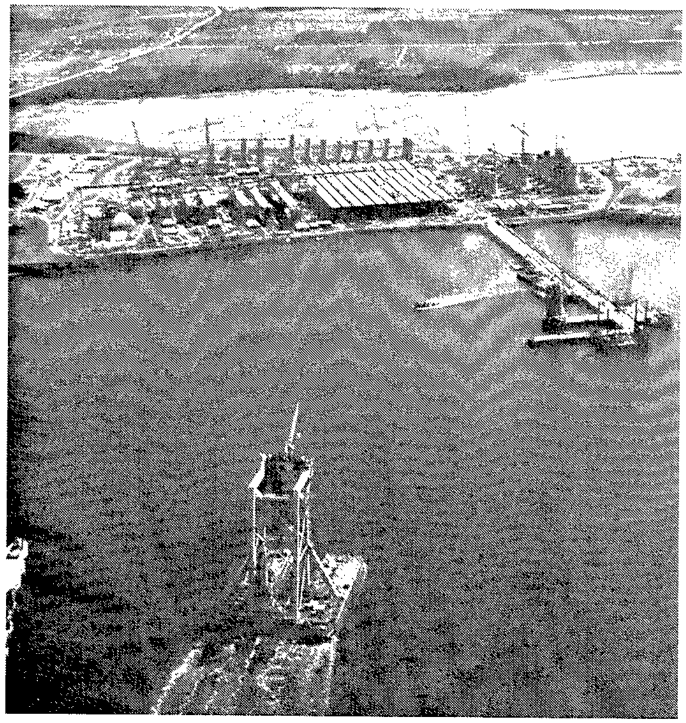


Figure 14. The *Svanen* approaches the 500-m-long jetty to pick a pier base

Placement of these main bridge components was followed by extensive post-tensioning operations. Post-tensioning was used to tie the main girders to pier shafts, pier shafts to pier bases, and continuous drop-in girders to the main girders on either side.

The project officially began on October 3, 1993, when the contract was signed. By the end of 1994, the 668,000-m^2 (165-acre) Amherst Point farmland had been turned into a precast yard. Prefabrication of the bridge components was carried out during the winter season of 1995-96. The first pier base was placed underwater on August 7, 1995. On November 19, 1996, the *Svanen* placed the last structural component, the drop-in girder between Piers 34 and 35. On May 30, 1997, the Confederation Bridge was formally open to traffic.

Bonneville Lock Guidewall, Oregon

The Bonneville Lock guidewall consists of five precast concrete segments. The segments were designed as floating pontoons to be towed to the lock site individually. One of the segments became a permanent floating guidewall. The other four segments were fixed onto 52-ft-diam (16-m-diam) sheetpile cells as a part of the fixed guidewall. The floating guidewall is approximately 398 ft (121 m) long, 48 ft (15 m) wide, and 26 ft (8 m) deep. The permanently fixed concrete segments are approximately 33 ft (10 m) wide and 13 ft (4 m) deep, and range in length from 1 ft (25 m) to 150 ft (46 m).

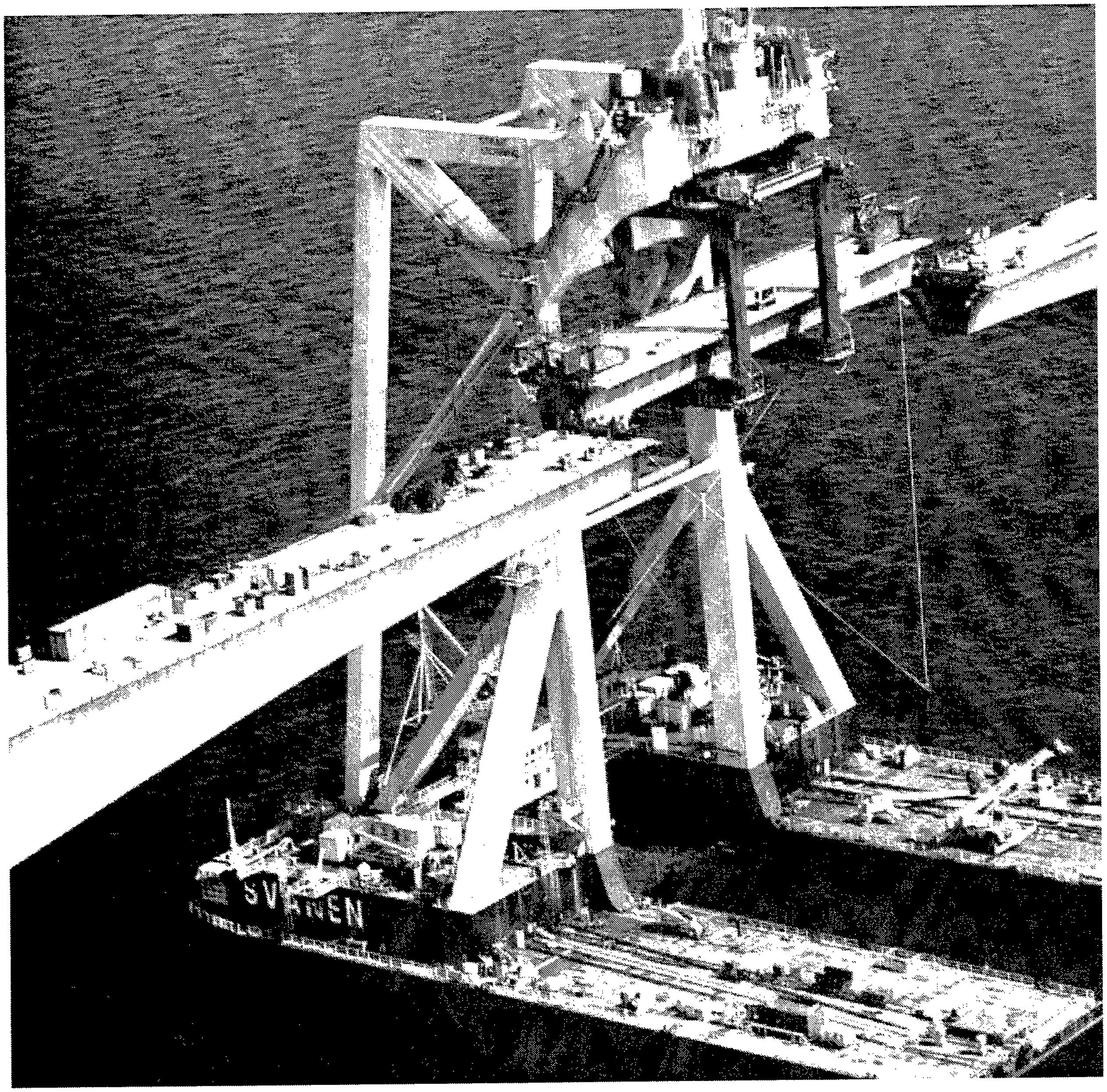


Figure 15. Placing the last drop-in girder segment to complete the bridge

These segments were prefabricated within an earth berm graving dock in Boardman, OR, about 40 miles (64 km) upstream from the project site. Once arriving at the site, the segments were lifted partially off-water to seat on 39-in. (1-m) square elastomeric bearings on the cells with vertical keyways. They were then attached with a restrainer bracket. Each segment weighs more than 4,000 tons in dead weight. With the assistance of partial buoyancy, the actual lifted weight is still in the range of 600 to 800 tons.

The contractor built a piece of custom-designed lift equipment to accomplish this lift-in operation. The lift equipment consists of two large lift girders and

strand jack systems. The lift girders extend out to the side of the barge to allow the strands to strap around the pontoon segment (Figure 16). Once the jack systems started to lift the segment, the opposite side of the barge was promptly ballasted to keep lateral stability and trim of the barge. The barge was then positioned to an installation location and ballasted down to let the concrete segment seat onto the vertical keyways of the cells. The project was successfully completed in 1992.

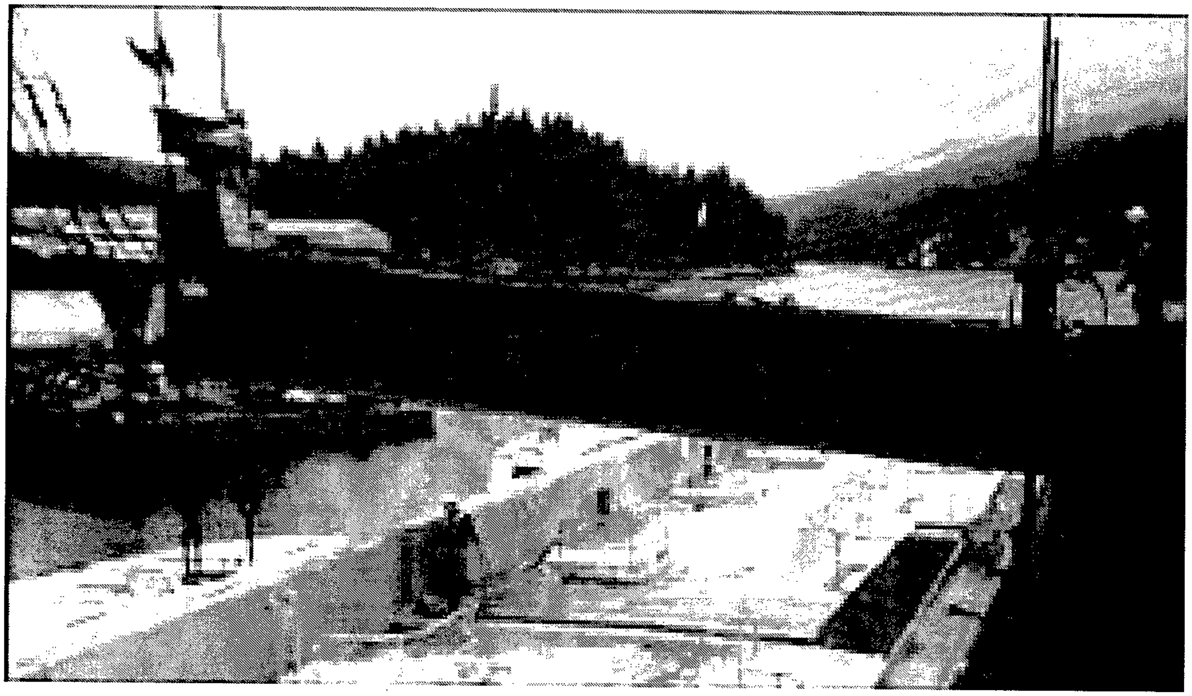


Figure 16. Bonneville Lock guidewall installation, showing the process of lifting float-in wall segments with lift girders and strand jacks

Selection Criteria for Heavy-Lift Equipment

In the lift-in method, the number of precast components and underwater joints between these components has significant implications on the construction cost and logistics. Underwater joining of precast concrete components is costly, and the installation of numerous small concrete components may adversely affect the project cost, schedule, and quality control. For large projects, use of large crane barges with high lift capacity is generally the most cost-effective method of installing precast modules underwater.

The ability to minimize the number of underwater joints and the number of precast segments is a compelling argument in favor of using large precast concrete components. However, there are practical limitations on the size and weight of the precast segments, such as equipment availability, structural capacity of lifting equipment, physical site access, and economics. In addition, the handling stresses and structural rigidity of individual modules will also place an upper bound on their practical size and weight. The maximum size of the precast modules is

governed primarily by the lift capacity of the crane barges. In principle, the cost of lift equipment increases significantly with its increasing lift capacity. Thus, an evaluation of the optimum shape, dimensions, and weight of precast modules must include a cost analysis of the lifting equipment.

Selection of the lift equipment also requires careful evaluation of specific project constraints on lift equipment. The common constraints are the dimensional limitation imposed by the width of nearby locks through which the equipment has to pass, the draft and width of the equipment imposed by the depth and breath of river navigation channels, overhead clearance under bridges and power transmission lines, and the floating stability requirement. The limitations on lifting equipment typically include the height, width, draft, and maneuverability of floating crane barges. For example, most bridges across inland waterways have only 12- to 25-m (40 to 80-ft) headroom clearance for passage of crane barges at low-water stages. This headroom clearance requirement practically excludes the use of many large offshore crane barges.

Salvage value and utilization rate of heavy-lift equipment are two significant cost factors. Owning an expensive piece of lift equipment may not result in higher cost, provided there is a reasonably good market demand for the equipment and its depreciation rate is low. For example, fully revolving derrick crane barges generally have a depreciation rate of 3 to 5 percent per year, compared with 40-percent depreciation for shear-leg cranes. Thus, a contractor may have to pay a premium price for a revolving crane barge in order to complete a specific project, but he also gets high return on the investment when the equipment is sold at the end of the project.

A high equipment-utilization rate represents high efficiency in construction planning and logistics. Lift-in construction of navigation structures often requires intermittent use of very large and costly lift equipment (up to several thousand tons per lift) to install massive precast concrete elements during specific periods of time. These lifting operations may be concentrated in windows of time spanning 3 to 5 months, depending on seasonal and project site conditions. There may be several such work windows during the life of the project. These infrequent, but extremely large, lifts may be followed by a relatively large number of smaller lifts (say 100 to 450 tons), as relatively light precast components are added to the structure and foundation. Large crane leases may require a minimum rental period (say 3 months). A higher rental rate will incur if the lease period is shorter than the minimum.

The equipment-utilization rate also impacts the amount of money that can be economically spent on very expensive heavy-lifting equipment. For example, a hypothetical project might be designed around lifting 3,000-ton maximum foundation elements or, alternatively, twice as many 1,500-ton elements. Since heavy-lift equipment costs increase at a disproportionate rate (i.e., a 3,000-ton lift system costs more than twice as much as a 1,500-ton lift system), the "least-cost" solution may very well be installing twice as many of the smaller elements. Care must be taken to select the maximum design lift size to yield a least-cost solution.

Equipment availability is another key consideration in the equipment selection. The global market contains a finite number of lift equipment capable of making very heavy lifts. This equipment is expensive, typically operates under long-term commitment contracts, and requires lease payments even when idle. As noted above, extremely heavy lifts are usually infrequent and sometimes spread over an extended period of time. This may lead to excessive rental and standby costs. Clearly, there are economic limits to selecting the maximum segment weight for a lift-in operation.

The lift equipment and installation techniques must be capable of placing the largest elements to within the required tolerances (typically in the range of 13 to 51 mm (0.5 to 2 in.)). These tolerances are best met by lifting the component into position, as opposed to ballasting a component into position in the float-in construction. This lift-in approach typically allows tighter positioning tolerances compared with the float-in approach. The positioning tolerances for installation of the precast modules have an important influence in selection of heavy-lift equipment. A stable crane barge, such as a jack-up barge, can accommodate much tighter placement tolerances than a floating crane barge.

The stability and maneuverability of the crane barge are important criteria. For example, while a fully revolving derrick crane barge offers the highest flexibility in picking and placing lift-in elements, its lifting capacity can be severely limited by the list of the barge when lifting and placing loads on its beam. On the other hand, a jack-up crane barges does not experience any floating instability as other floating cranes do, but its maneuverability is limited by its fixed jack-up position and the limited reach of the crane. The requirements on the stability and maneuverability of lift equipment are project specific and, to a large extent, depend on such factors as the shape and size of precast components, the positioning tolerances and logistics of placing the components, and the river conditions (river flow velocity, draft, etc.).

Environmental factors such as the riverflow velocity and allowable work window affect the lift-in operation. Thus, the river conditions during installation must be considered in selecting the lift equipment. In general, available meteorological and hydrological statistics for the site for the anticipated installation work window should be studied prior to selecting a particular type of lift equipment.

The method of transporting the modules from a prefabrication site to the project site also plays an important role in selecting lift equipment. One method is to have the heavy-lift equipment retrieve the modules directly from the prefabrication yard and deliver them to the site. This method may not be efficient unless the prefabrication yard is located in the vicinity of the project site. A viable alternative is to load the precast segments onto a barge for delivery. This allows the heavy-lift equipment to remain in position at the site. This alternative allows maximum productivity during segment installation at the expense of adding a delivery barge.

In summary, a variety of crane barges are suitable for lift-in construction. Selection of lift equipment should be based upon careful evaluation of project-specific requirements, including the following:

a. Weight, size and shape of precast components to be installed.

b. Availability of the lift equipment in the commercial market.

c. Cost of the equipment (initial cost and salvage value).

d. Equipment-utilization rate.

e. Logistics of positioning precast segments at the site.

f. River condition at the time of construction (riverflow velocity, water elevation, allowable work window, etc.).

g. Navigation restrictions along the access route for the crane barge, e.g., the bridge overhead clearance, width and length of the lock, draft requirement at low water during construction.

h. Maneuverability of the crane barge and its productivity for intended operations.

i. Floating stability and the ability of the equipment of positioning prefabricated modules within prescribed tolerance.

j. Meteorological and hydrological conditions onsite for the anticipated lift work window.

k. Method of transporting precast components from the prefabrication yard to the project site.

l. Navigation traffic through the site during lift-in construction.

In Chapter 3 of this report, various types of lift equipment will be evaluated on the basis of the above requirements.

Specification Requirements for Typical Crane Barges

To select the most suitable crane barge for a specific lift-in project, the operating parameters and restrictions should be established on the basis of the selection criteria outlined in the previous section. These parameters allow use of a parametric model to investigate various barge configurations. This model can be used to determine the minimum barge length, depth, width, and static counter-ballast weight that comply with the barge stability and strength requirements.

Design, construction, and operation of a crane barge should comply with the safety requirements specified in EM 385-1-1 (HQUSACE).[1] Section 16.F of the manual specifically addresses the safety requirements regarding construction, stability, design load conditions, and environmental considerations of floating cranes and floating derricks.

A crane barge should meet inland waterways regulatory requirements established by the U.S. Coast Guard and classification authorities such as the American Bureau of Shipping. For example, the American Bureau of Shipping specifies a minimum standard for construction of crane barge hulls in its publication "Building and Classifying Steel Vessels for Service on Rivers and Intracoastal Waterways." With respect to the crane operation, the contractor should retain the following documentation prior to construction:

a. Certification of classification of the crane.

b. Crane test and installation report.

c. Load-radius curves for static and dynamic lifting condition.

d. Instructions for crane operation, including limiting parameters (wind speed, roll/pitch angle, etc.).

Crane foundations should be designed to act as complete supports against vertical and racking loads independent of the casing frame, bed plate, or other part of the supported unit. Wherever possible, longitudinal and transverse bulkhead intersections are placed beneath the crane foundations, minimizing the amount of foundation structure required.

The crane barge usually has at least four ballast tanks in the forward end opposite the crane. The tanks are required to trim the barge by the bow during installation of the lift-in modules and when there is no load on the crane. Ballast pumps of the deepwell turbine-type are provided in the pump room—one located over each forward ballast tank, port and starboard. The deepwell turbine pumps should be self-contained, removable assemblies containing the drive shaft, shaft bearing, and impeller in a single tube. The pump tube assembly is inserted into a fabricated pump barrel extending through the main deck to the bottom of the ballast tank forward.

Before positioning a crane barge for lift operations, a mooring/anchoring plan should be developed. The holding capacity of the mooring arrangement should be sufficient to hold the barge in position during the lifting operations. The mooring plan should also describe the operation position as well as the standoff position and the procedure for moving clear of the structure in question.

Deck engines are a key component to accurately maneuvering and holding the barge in position during installation of precast segments. Normally, at least four

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[1] Headquarters, U.S. Army Corps of Engineers. (1996). "Safety and health requirements manual," Engineer Manual 385-1-1, Washington, DC.

double-drum winches are needed to provide accurate positioning control of a barge. For inland waterways marine work, at least eight taut mooring lines are needed for positioning. These lines typically pass through fair-leads positioned at the four corners of the barge and extend to preset anchors or mooring piles. The fair-leads should be sized with sheaves at least 20 times the diameter of the wire rope.

To allow efficient coordination of deck engine and crane operations, survey and positioning operations should take place from a central control console on the barge. The control console contains all the crane hoist and mooring winch controls. The control house and survey room are usually located in a midship deckhouse.

A deckhouse usually contains other auxiliary machinery, including generators, switchboards, and pumps. Diesel generator sets are used to supply general power and lighting needs. An independent power generator set is used for navigation, communications, and survey equipment.

Electrical distribution can be provided by a split bus main switchboard in the generator room, providing distribution to all loads except ballast pumps. The ballast pumps can be powered from a second bus, interlocked so that the second generator must be started to supply this bus separately. Automatic bus transfer can be disabled while ballast pumps are operating.

All deck equipment aboard the barge should have local day tanks and a fuel service system. The fuel storage and transfer system should include an independent deck tank with direct supply and return to generators and hose reel stations to supply other equipment.

The barge should be equipped with a high-pressure service water supply system for firefighting and deck washdown. The high-pressure water main should run the entire length of both the port and starboard sides of the barge. The service water pump assembly should be a self-contained unit, similar to the ballast system pump, with the pump barrel and suction tube arranged so that the impeller extends approximately 1.5 m (5 ft) below the lowest anticipated river water level.

A compressed air system should be provided to supply service air to the tool room for pneumatic equipment and to supply dried and filtered control air to the crane and mooring winches.

Other deck outfits include lifesaving equipment (rescue boat, etc.); bilge system; sanitary drain system; heating, ventilation, and air-conditioning system; and portable water system for drinking, washing, and engine cooling makeup.

3 Heavy-Lift Equipment Evaluation

The preceding discussion has identified many of the issues surrounding heavy-lift operation requirements. Key elements—such as precast component size, delivery method, and equipment utilization—help to select the proper type of lift equipment for a specific project. Within this framework, the following types of heavy-lift systems are evaluated:

a. Lattice-boom heavy-lift crane, ringer- or pedestal-mounted on floating barges.

b. A-frame type (shear-leg) crane barges.

c. Offshore crane barges.

d. Jack-up barge crane barges.

e. Catamaran barges with lifting beams or gantries.

f. Catamaran barges with linear jacks/rods.

g. Float-over system.

h. Versatruss lift system.

There is no single lift equipment or lift method that is optimum for all conditions. Each of the lift systems has its own distinct characteristics in terms of suitability and applications. Factors that should be considered in selecting a system for inland waterway use are listed below.

a. Buoyant weight and physical dimensions of precast elements to be handled.

b. Physical restrictions for the lift equipment to access the project site.

c. Lead time for procurement of lift system (purchase, assembly, or rental).

d. Lifting equipment utilization rates (capital costs associated with idle equipment).

e. Initial investment in procuring lifting equipment.

f. Lifting equipment salvage value and/or disposal costs.

Fully Revolving Derrick Crane Barges

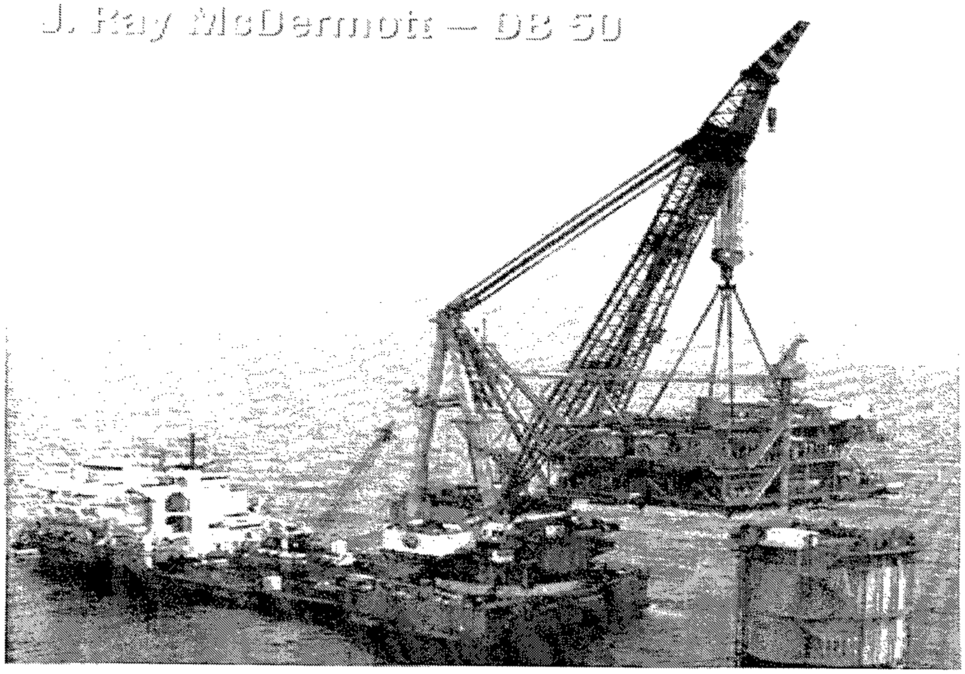
A typical revolving derrick barge consists of a lattice-boom crane mounted on a floating barge using either a permanently fixed tub or a ringer attachment (Figure 17). Due to structural and naval architectural reasons, the revolving derrick crane is usually located forward of the stern a distance 20 to 25 percent of the barge length. Furthermore, the barge should be wide enough to minimize list as the crane swings and to provide adequate load distribution. In comparison with a land crane, a marine derrick generally uses a large swing circle that moves the boom seat closer to the barge edge while maintaining the center of rotation and adequate support well back.

In comparison with other types of crane barges, the fully revolving derrick barge has many advantages in operation. It has the ability to pick loads off a barge or boat alongside the derrick, or even off the deck of the derrick barge itself. It has the ability to follow the surge motions of a boat or barge alongside, to pick a load from off it. It can also orient itself in the most favorable direction to minimize its boom tip displacement and accelerations. In addition, it has excellent control in positioning precast components, because it is able to quickly reach any point in three-dimensional space with one set of controls.

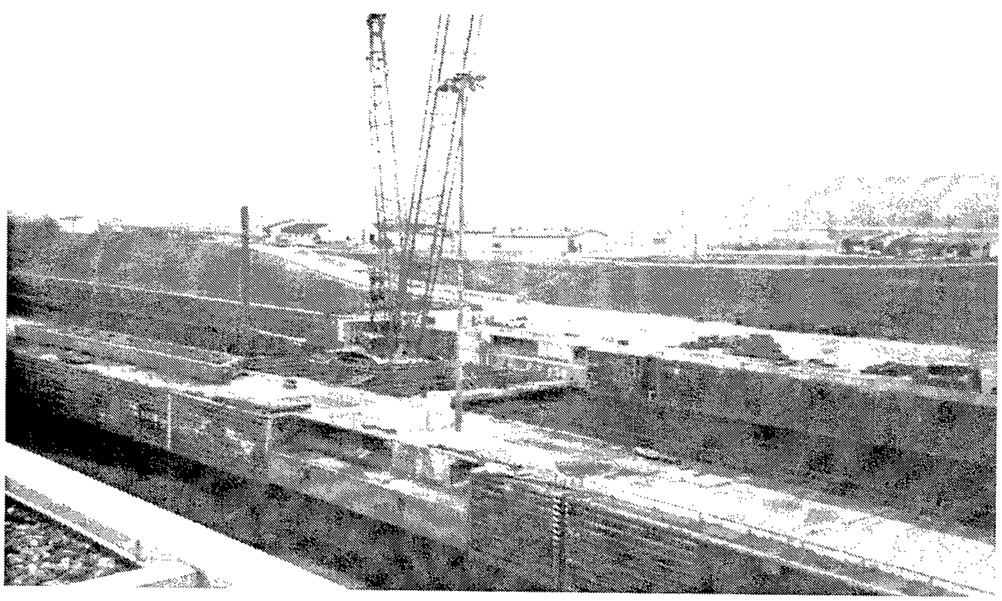
When setting large and heavy loads, the boom tip motions control the positioning. These motions are affected by motions of the barge, such as list and trim. When a crane booms far out over the stern, the motions of the boom tip are significantly amplified by list/trim of the barge. When working "over the side," stability of the boom tip is affected by roll of the barge. A potential hazard develops when an unexpected surge or sway of a crane barge forces the crane to lift loads beyond its capacity. The consequence of such an incident may be a direct failure of the boom or a loss of swing control and capsizing. Therefore, derrick barges are normally fully moored in position and remain stationary during a lifting operation. All movements of the barge, laterally or longitudinally, are controlled by the mooring system and deck engines. With taut mooring and torque converters, positioning of barges can be achieved with a tolerance of 50 mm (2 in.).

Controlling the list of revolving derrick barges is the overriding concern in some lifting operations. The list must be controlled during rotation of the boom under fully loaded or no-load conditions. The counterweight is usually designed to limit the list under full load. Hence, once load is released, the barge under no-load may list toward the opposite side. Offshore derrick barge cranes are fitted with automatic warnings to signal improper combinations of load and boom radius. Computer monitoring systems have been developed to enable control of the dynamic aspects of lifting operations. These systems consist of sensors on the crane barge, the crane boom, and the cargo barge. Such minicomputers typically

give out readings such as "load on hook," "outreach (radius)," "hook height," "wave height," etc.



a. Offshore derrick barge (497 × 151 × 45 ft) (lift capacity: 4,400 tons)



b. Typical revolving derrick barge for light lift in inland waterways works (lift capacity: 250 tons)

Figure 17. Offshore and typical revolving derrick barge—lift capacity

To pick a light load from a supply boat, a single line is preferred. It can raise the load fast enough to prevent an impact on the subsequent heave cycle. Raising a heavy load from a barge may involve 24 parts or more in the line. The barge will heel or pitch down as the load is lifted. When lowering and setting the heavy load onto supports, the reverse occurs. As the load is set, the lowering line must overhaul through 24 parts, while the barge raises up due to reduction in load.

A load suspended from a boom tip is a pendulum. While the load line length is usually too long for direct resonance, the load may tend to get dynamic amplification from low-frequency energy of barge motions. The common practical solution is to raise or lower the load quickly through those positions that develop amplified responses.

Before mounting any type of crane aboard a barge, it is imperative that the deck beams and framing be checked to ascertain that the deck can carry the load from the crane operation. If the framing is of adequate strength, sufficiently large plank (such as mats and I-beams) should be used to spread the load over a number of frames, so that the deck framing system will not be overstressed. Furthermore, a naval architecture check should be carried out to evaluate the floating stability of the barge for the anticipated loads at an anticipated working radius.

For the purposes of this study, we will consider a Manitowoc 888 heavy-lift crane equipped with a ringer attachment mounted on a floating barge 240 ft long by 80 ft wide (73 by 24 m). Two side-mounted sponsons (100 by 10 by 13 ft deep) will be used to control barge list when lifting over the side of the barge. (Technical information for this equipment is provided in Appendix A.)

Land cranes have narrow booms. They are unsuitable for lifting heavy loads while floating, unless restrictions are imposed on barge list. Marine cranes are usually designed to work under their rated loads up to 3 deg "machine list," which is the amount of tilt that the cranes can safely experience during lifting operations. The load-capacity ratings for marine cranes are based on 1- or 2-deg roll at a period of 10 to 12 sec, which equates to an acceleration of 0.07 g's.

Manitowoc produces load charts for barge-mounted cranes under varying amounts of machine list. As shown in the example chart presented as Figure 18, the crane lifting capacity decreases rapidly with increasing machine list. In general, revolving crane barges should be designed to limit machine list to 3 deg in the transverse direction. For a given amount of load, machine list is a function of barge size and the proper use of sponsons. Appendix A contains load charts for a barge-mounted Manitowoc crane 888 model with machine lists of 1 and 2 deg.

Capacity

Lifting capacities of a fully revolving derrick barge depends to a large extent on two factors: the structural capacity of the crane for a given machine list and working radius, and the floating stability of the barge itself. Lifting capacities are greatest if the lift can be limited to just off the stern of the barge. A lesser capacity

Manitowoc Cranes, Inc.
Manitowoc, Wisconsin 54220 U.S.A.

Liftcrane Boom Capacities

2250 SERIES 3

Boom No. 44 With Heavy Lift Top
249,200 Lb. Crane Counterweight
120,000 Lb. Carbody Counterweight
Crawler Machine on a Static Barge
0 Degree thru 3 Degree Static Machine List
No Travel - 360 Degree Rating

Oper. Radius Feet	Boom Angle Deg.	Boom Point Elev. Feet	0 Degree List Boom Capacity Pounds	1 Degree List Boom Capacity Pounds	2 Degree List Boom Capacity Pounds	3 Degree List Boom Capacity Pounds	Oper. Radius Feet
80 Ft. BOOM							
20	82.4	86.9	526,400 *				20
21	81.7	86.7	523,600 *	430,000 *			21
22	80.9	86.5	521,000 *	428,100 *	317,700 *		22
23	80.2	86.3	518,500 *	425,700 *	317,700 *		23
24	79.5	86.1	505,700 *	422,100 *	317,700 *	249,100 *	24
25	78.7	85.9	486,400 *	418,700 *	317,700 *	249,100 *	25
26	78.0	85.6	468,500 *	415,300 *	317,700 *	249,100 *	26
27	77.3	85.4	451,900 *	412,000 *	317,700 *	249,100 *	27
28	76.5	85.1	436,300 *	408,800 *	317,700 *	249,100 *	28
29	75.8	84.8	421,800 *	399,100 *	317,700 *	249,100 *	29
30	75.0	84.5	408,100 *	386,800 *	317,700 *	249,100 *	30
32	73.5	83.9	383,200 *	364,300 *	316,000 *	249,100 *	32
34	72.0	83.2	361,100 *	344,200 *	296,600 *	249,100 *	34
36	70.5	82.4	341,300 *	326,100 *	279,400 *	242,900 *	36
38	68.9	81.6	323,400 *	309,400	264,000 *	229,300 *	38
40	67.3	80.7	300,700 *	287,900	250,100 *	217,000 *	40
42	65.8	79.8	280,400 *	269,100	237,500 *	205,900 *	42
44	64.2	78.7	262,500 *	252,500	226,100 *	195,900 *	44
46	62.5	77.6	246,300 *	237,700	215,700 *	186,700 *	46
48	60.9	76.5	231,700 *	224,400	206,100 *	178,200 *	48
50	59.2	75.2	218,600 *	212,100 *	197,300 *	170,500 *	50
55	54.8	71.7	190,600 *	185,700 *	178,100 *	153,500 *	55
60	50.2	67.6	167,800 *	164,100 *	160,600 *	139,400 *	60
65	45.1	62.7	149,000 *	146,100 *	143,400 *	127,400 *	65
70	39.6	56.8	131,600 *	129,500 *	127,400 *	117,100 *	70
75	33.3	49.4	111,400 *	109,900 *	108,500 *	107,200 *	75
80	25.4	39.7	92,700 *	91,700 *	90,800 *	90,000 *	80

Figure 18. Lift capacities of Manitowoc Crane 2250 for different machine lists and working radii

will occur if the crane must rotate an angle up to 360 deg, which may be important in maintaining good production rates when setting multiple elements.

To determine lifting capacity of a derrick barge, both the allowable machine list and floating stability of the barge should be checked for various lift loads and required working radii. As an example, the lift capacities of a ringer-mounted Manitowoc 888 crane barge are calculated. Figure 19 shows the procedure of calculating the machine list and barge stability for a given load at a working radius. Appendix A contains detailed calculations of allowable lift capacities for various working radii of the crane boom, assuming either 360-deg boom swing or lifting over the stern only. The study indicates that the lift capacity of the fully revolving Manitowoc 880 will be limited by the machine list on a 240- by 80-ft barge when lifting loads over the side of the barge. When side-mounted sponsons (counterweight tanks containing ballast water) are used to control the list, the lift capacities can be significantly increased.

Evaluate Floating Rig Capacities - 360 degree Rotation

Crane Type: Manitowoc 888 Ringer with No. 67B Boom

Diameter of Ringer Assembly (Gross width) =	51.2	feet
Est Height of Center of Gravity (above deck) =	15.2	feet
Estimated Boom Length =	125.0	feet
Maximum allowed boom angle =	70.0	degrees
Est. weight of basic crane (excl CWT & boom) =	573,610	lbs
Estimated total Counterweight (excluding crane) =	1,395,100	lbs
Crane Load (tons, incl load block + rigging) =	427.0	tons
Operating Radius from Center Line crane rotation =	50.0	feet
Calculated Boom Tip Elevation (above deck) =	125.9	feet
Estimated weight of boom =	35,360	lbs

Note: Clearance between ringer and edge of barge (crew walkway) is 14.4 ft to barge side and 5.0 feet to stern of barge

Barge Data

Barge Length overall =	240.0	feet
Barge Width overall =	80.0	feet
Barge Depth overall =	15.0	feet
Navigational Draft =	6.0	feet

Barge Ballasting (optional)

Sponson Dimensions: 100 feet long by 10 feet wide by 13.0 feet deep

Percent Sponson ballasted:	71.0	percent
Added "Free Surface" water ballast (front of Barge)	30.0	feet (front compartments of barge may be flooded for ballast)
Calculated Draft with crane + sponson (no load) =	8.1	feet
Calculated Draft with crane and load =	8.8	feet

Calculate Center of Gravity, Buoyancy, BM and GM

Center of Gravity above keel with load (KG) =	22.5	feet above keel
Vert. Dist. to Center of Buoyancy with load (KB) =	4.4	feet
BM (longitudinal), corrected for free water =	386	feet
BM (transverse), corrected for free water =	53	feet
GM (longitudinal), corrected for free water =	368	feet
GM (transverse), corrected for free water =	35	feet

Calculate Machine List

Total Weight (Barge + Crane + Sponson + Load) =	13,985,804	lbs
Longitudinal Listing Moment =	42,700,000	ft-lbs
Transverse Listing Moment =	16,782,160	ft-lbs due to load, including the effects of the sponson counter wt

Machine List if load over side =	1.98	degrees. Reach is	10	feet over side of barge
Machine List if load over stern =	0.48	degrees. Reach is	19	feet over stern of barge

Figure 19. Calculations of the machine list and barge stability for Manitowoc 888 mounted on a 240- by 80-ft barge with two sponsons

For making lifts in inland waterways, revolving derrick barges traditionally have a maximum lift capacity of 500 tons. Since the beam width of a crane barge is limited to the width of locks, the use of a crane capacity exceeding 500 tons may lead to unacceptable machine list when lifting a heavy load on the side of a barge, unless side-mounted sponsons are used.

Table 1 lists the capacities at various operating radii, assuming 360-deg rotation and directly over the stern. In all cases, the crane's structural capacity is the limiting factor in how much load can be lifted, rather than just relying on barge stability (provided that sponsons are used while the machine is operating over the side).

Table 1
Maximum Lift Capacity at Various Operating Radii

Operating Radius (ft)	Lift Capacity (tons) for Manitowoc 888 (360-deg)	Lift Capacity (tons) for Manitowoc 888 (over-stern)
45	453	519
50	427	486
55	404	457
60	384	432
65	366	409
70	350	388
75	335	369
80	321	352
85	301	337
90	284	322
95	268	309
100	254	288
110	229	254

The lift equipment possesses lifting capacities in the range from 457 tons at a 55-ft radius directly over the stern, down to 229 tons at a 110-ft radius with full-swing capability. For a given working radius, the maximum reduction between "over-the-stern" versus "360-deg rotation" lifting capacity is about 15 percent. (This is the benefit of using a ringer attachment and a relatively stable barge platform due to the use of sponsons.) If sponsons are not used, the reduction of lifting capacity for picking loads over the side could be over 40 percent. In general, these crane capacities appear sufficient to handle a significant proportion of heavy-lifting operations in inland waterways.

Availability

Heavy-lift cranes up to 500-ton lift capacity are readily available for both purchase and lease in the United States, although the lead-time required for purchasing or leasing may run up to 6 months. There is also a significant supply of used barges for lease or purchase. The equipment can be delivered in separate components to the site and assembled within 4 to 6 weeks. Because the system is delivered in components to the job site, there are no significant river draft or overhead clearance restrictions. In general, approximately 3 to 6 months lead-time may be required to purchase all the equipment components and to assemble a heavy-lift revolving-derrick barge on the job site. Testing and obtaining operation certifications may require an additional 2 to 3 months.

On the other hand, typical offshore revolving-derrick barges have lift capacities ranging between 50 and 13,000 tons at 120-ft working radius. In an offshore derrick barge, the lattice-boom crane is permanently attached to a steel "tub" support integral with the barge deck (as opposed to the Manitowoc 888 alternative, which is temporarily mounted on a barge via a ringer attachment). A later section of this report (pages 44-55) presents further discussion on the availability and economy of these offshore crane barges.

Mobility

The revolving derrick barge is the most versatile lift equipment for installing prefabricated modules over water. It has excellent positioning control and can quickly reach any point in three-dimensional space with one set of controls. The mobility and versatility of the revolving derrick barge can be used to significantly increase productivity of lift-in operations.

During transportation (without the crane), a typical barge requires less than 5 ft of draft, allowing the barge to travel through the inland waterways route. Overhead height restrictions are not significant since the ringer crane can be installed at the job site.

Economics

There are two primary solutions for providing marine "hook service" to a particular construction site. The first solution is to mobilize and demobilize lifting equipment each time heavy-lift "windows" appear in the schedule. An alternative solution is to purchase and/or assemble heavy-lifting equipment for the project, mobilize only once, and operate equipment whenever lifts are required. The equipment is idle when not required. The least costly solution is a function of equipment utilization rates, the duration of the project, and purchase versus lease decisions. In general, the equipment selection will not depend on the cost alone. The contractor's decision is often influenced by his cash-flow consideration and credit rating.

Equipment costs are highly sensitive to assumptions made regarding contract duration, buy versus lease parameters, and equipment utilization factors. In Appendix A, cost analyses is carried out on a Manitowoc 888 crane barge (240 by 80 ft in size) in terms of several assumed conditions of contract duration, equipment utilization, and ownership (buy versus lease).

Three basic cases are assumed in the analyses: a 1-year project duration with a 100-percent equipment utilization rate; a 2-year project duration with a 50-percent equipment utilization rate; and a 3-year project duration with a 50-percent equipment utilization rate. For each case, both the "buy-and-salvage" option and the leasing option are evaluated.

Figure 20 shows the basic procedure and assumptions made in the cost analyses of the buy-and-salvage option. Since the revolving crane has a high salvage value, it is assumed that the depreciation rate of the Manitowoc 888 is 5 percent per year. The lump sum depreciation of the barge is 20 percent of the initial cost for the project. The cost of capital (interest accumulated during a project period) is assumed to be 8 percent, and the sales tax is 7 percent. The sum of the depreciation value, the sales tax, and the cost of capital is the cost of ownership. The sum of the ownership cost, mobilization/demobilization cost, and operation cost is the net cost of using the lift equipment.

For the buy-and-salvage option, the analyses show that the cost would be approximately $2.9 million for a 1-year project with 100-percent equipment utilization. The cost would increase to $3.8 million and $5.1 million for a 2-year or 3-year project, respectively, assuming 50-percent equipment utilization (i.e., the lift equipment is used for 6 months in a year).

For the leasing option, the cost would be approximately $3.2 million if the equipment is leased and operated for 1 year with 100 percent utilization. The cost would increase to $3.6 million and $5.4 million when leasing the equipment for a 2-year or a 3-year project, respectively, assuming 50 percent equipment utilization. It is apparent that the buy-and-salvage method gains significant financial advantage if the equipment works 6 months per year for a 3-year period.

The analyses indicate that, for most cases, it is economical to purchase the crane barge at the start of the project, charge the cost to the project, and salvage the equipment at project completion. This conclusion with regard to the revolving derrick barge may be equally applied to other types of crane barges, provided the contractor has enough cash or credit to make the initial purchasing investment. This economic reality occurs for two reasons. First, the revolving cranes generally have very high salvage value so that the buy-and-salvage method can achieve relatively small depreciation of the crane. Second, leasing companies often require a minimum lease period (typically 6 months). Thus, high lease costs are incurred even for brief periods of actual lifting time. On the other hand, mobilization and demobilization costs are usually significant, which would occur each time a short-term lease is initiated.

Purchasing equipment and salvaging at project completion has other, indirect advantages over leasing equipment:

a. Equipment ownership reduces out-of-pocket expenses to the contractor if construction is delayed and the equipment is required beyond the estimated time period.

b. Equipment ownership eliminates the risk of unavailable equipment during critical construction periods.

c. Equipment ownership allows for a full-time "hook" on the project for relatively little incremental cost.

Cost Analysis, Purchasing Option of Manitowoc 888 Crane Barge (1 Year Duration, 100% Usage)

Assumed duration of heavy lift crane use	1	years
Months out of each year crane operates	12	months per year
Cost of capital	8.0	percent
Sales Tax Rate	7.5	percent
Depreciation Rate, per year	5.0	percent (depreciation is generally low on large lift cranes - they can even appreciate)
No. of truck loads to move crane	60.0	each (there are 49 loads of just counterweight and ringer. Allow 10 more for crane and boom)
No. of shifts to Mob or Demob crane	6.0	each

Cost to Purchase Crane Barge			
Purchase cost of Manitowoc 888 Crane and Boom (new) =	$	1,650,000	(suggested price from Manitowoc)
Purchase Ringer Attachment for 888 (new) =	$	3,215,000	(suggested price from Manitowoc)
Purchase barge, 240' x 80' x 15' (used, w/mooring equip) =	$	3,000,000	(suggested price from Bisso Marine)
Total Purchase Cost =	$	7,865,000	
Cost of Capital for duration of lift crane use	$	629,200	
Sales Tax on purchase	$	589,875	
Crane Depreciation (use 5% per year)	$	243,250	
Barge Depreciation (say 20% lump sum)	$	600,000	
Total Ownership Cost =	*$*	*2,062,325*	

Cost to Mobilize and De-Mobilize Crane Once			
Cost to Transport Crane to Site	*$*	-	(included in purchase cost)
Cost to Transport Crane from Site	*$*	*96,000*	(16 hrs trucking per load x $100/hour trucking cost)
Cost to deliver barge to site	*$*	-	(included in purchase cost)
Cost to deliver barge from site	*$*	*75,000*	(say tug for 1 week at $10,000 per shift, plus $25,000 general expenses)
Cost to assemble Crane on site	*$*	*45,000*	(assume $7,500/shift to assemble crane - includes cost of 4100 helper crane)
Cost to dis-assemble Crane on site	*$*	*45,000*	(assume $7,500/shift to assemble crane - includes cost of 4100 helper crane)
Access trestle (100' x 50' @ $20/sf) to assmbl crane	*$*	*100,000*	
Total Mob/Demob Cost =	*$*	*361,000*	

Cost to Operate Crane							
Operators	1	ea x	1,920	hrs =	$	80,640	(Avg hrly labor cost is $42/hour)
Oilers	1	ea x	1,920	hrs =	$	61,440	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	2	ea x	3,840	hrs =	$	122,880	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1	ea x	1,920	hrs =	$	230,400	(assume $20/hour fuel, oil, and grease pluse $40/hour in parts and mechanic time)
Total Operations Cost =					*$*	*495,360*	

Equipment Rental Cost =	$	2,062,325	
Mobilization & De-mobilization =	$	361,000	(cost is for 1 mob and demob since the crane is purchased and remains on job)
Operating Costs =	$	495,360	
Total Cost =	$	2,918,685	

Figure 20. Cost analysis of a "buy and salvage" option for a Maintowoc 888 crane barge

d. Equipment ownership avoids multiple mobilizations and remobilizations. These operations are risky from a safety perspective.

One major disadvantage is associated with the purchasing and salvage option. The purchasing of large crane barges requires a significant outlay of cash, which may impose considerable demand on the cash flow of some contractors. On the other hand, equipment leasing may obtain some favorable rental agreement to improve the cash-flow situation.

There are exceptions to the above analysis results. For example, if a project requires only a few very heavy lifts within a short period of time (a few days to a month), it may be practical and economical to lease the lift equipment or to subcontract the lift work to a specialty company.

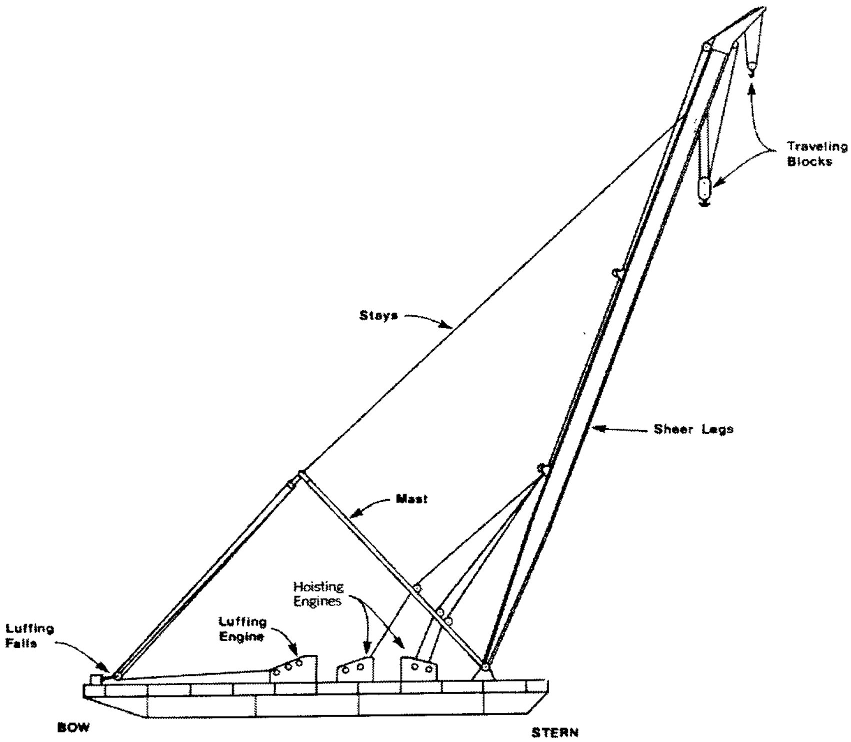
A-Frame Type (Shear-Leg) Crane Barges

A-frame shear-leg crane barges are generally the simplest and least expensive equipment for heavy lifts over water, with regard to both first cost and maintenance. These cranes typically are not self-propelled, but carry their own mooring equipment and crew accommodations. The equipment consists of a winch and block and tackle suspended from a pin-jointed A-frame, fabricated from two steel tubes held back by heavy stays to the bow (see Figure 21).

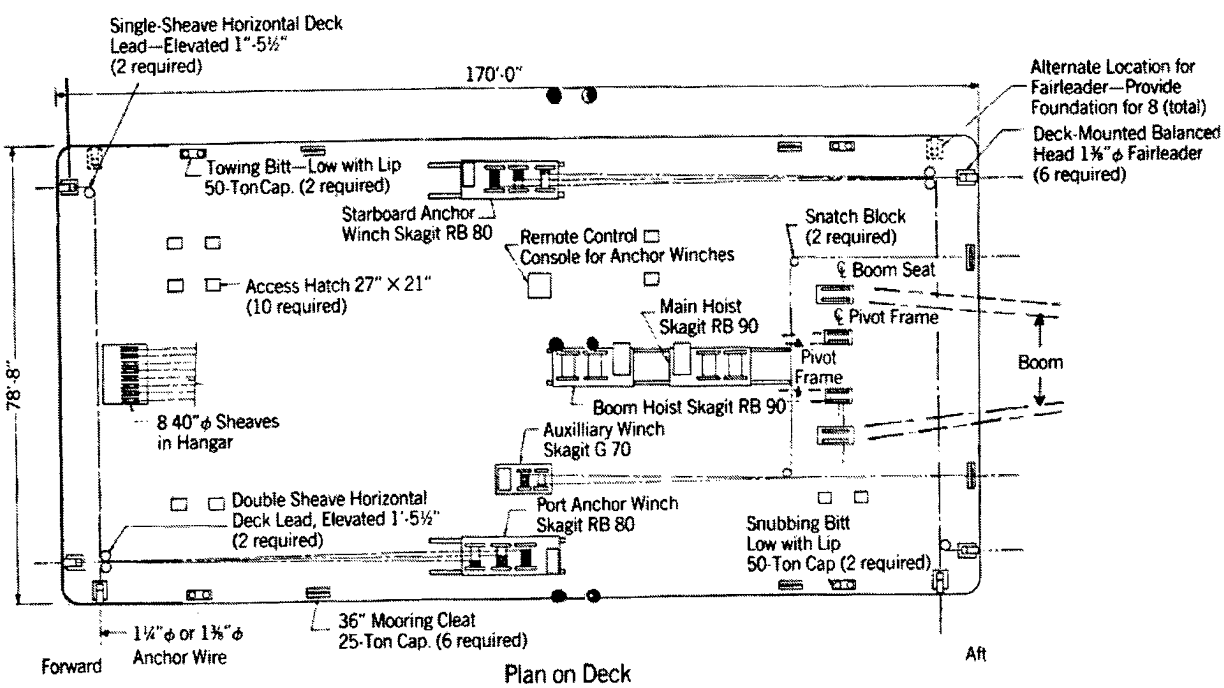
A shear-leg barge is normally capable of ballasting down by the bow, so as to offset the trim caused by lifting heavy loads. In comparison with the fully revolving derrick, shear-leg barges have the advantage of inherent stability during operation. That is, the shear-leg crane always picks the load over the stern, hence preventing list from the swing of the crane. These heavy-lift shear-leg cranes do not have the same degree of machine list limitations associated with revolving lattice-boom derrick cranes, so their lifting capacities are significantly higher.

A shear-leg crane can raise and lower loads but does not have any swing capability. This may be a significant disadvantage for certain applications. Horizontal positioning of loads is usually accomplished by movement of the barge. The crane barge moves in to the side of a cargo barge, picks a load, and then moves to the destination to set the load in exact position. To pick and set loads over water, the shear legs are usually fixed at an appropriate angle to serve both. Luffing of the shear legs (that is, raising the shear legs themselves while loaded) is awkward and slow. With torque-converter deck engines and calm water, lateral positioning can be achieved to a tolerance of 50 mm (2 in.).

Since the entire shear-leg crane barge needs to be well positioned to lift a load over the stern and then move again to set the load in exact location, shear-leg barges are less versatile in handling loads, and its operations are slower than those of a derrick barge. Furthermore, a shear-leg barge cannot choose its heading so as to minimize current forces and motion response to the currents and waves. However, shear-leg cranes are well suited for inland waterways because waves seldom exceed 2 to 3 ft.



a. Typical shear-leg crane barge (elevation)



b. Typical shear-leg crane barge (plan)

Figure 21. Elevation and plan for typical shear-leg crane barge

There are crane barges currently operating on inland waterways with lift capacities in excess of 700 tons. Shear-leg crane barges with up to 3,000-ton lift capacity are feasible for inland waterways construction. Shear-leg cranes can operate only off the stern of the barge. This limitation greatly reduces the versatility of the equipment for work that requires rotation during installation—such as "duty-cycle" production work, installing smaller precast segments on top of previously installed foundation segments.

For the purpose of this study, we shall consider a 200- by 70-ft floating barge equipped with a permanently installed A-frame and gantry designed to support the design loads (approximately 700-ton lift capacity at 130-ft radius) from a single hook. The shear-leg crane barge is similar to the *Cappy Bisso*, shown in Figures 22 and 23. It should be noted this example is for illustration and comparison purposes only. It is not meant to suggest this particular barge as the optimum choice. Appendix B contains technical information on a variety of shear-leg crane barges for reference.

Capacity

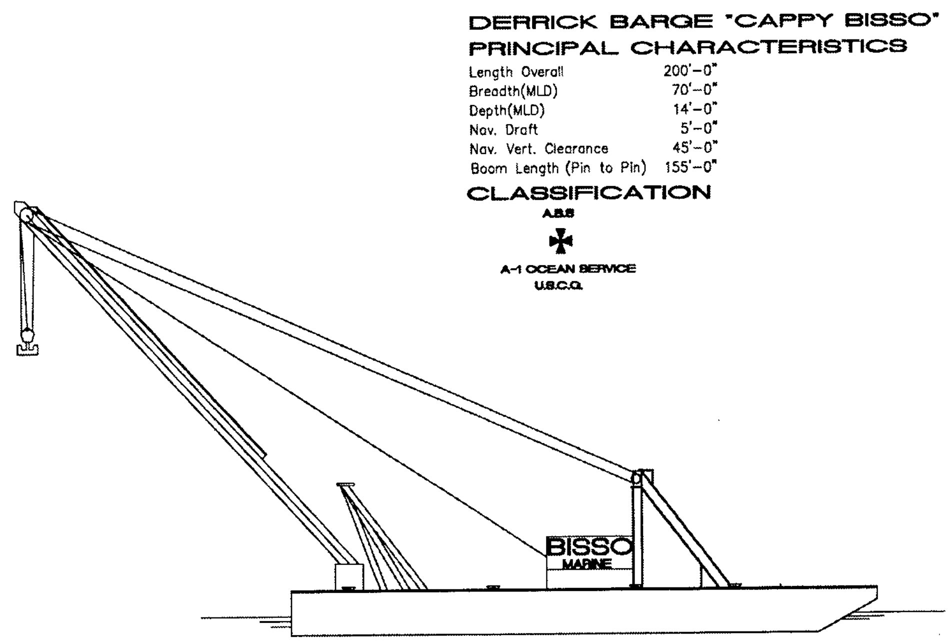
A shear-leg crane barge always picks load over the stern and luffs, but does not swing. Unlike a revolving crane barge, a shear-leg crane barge does not experience any significant problem with list in moving and positioning a load. The floating stability of the shear-leg crane barge allows it to reach its full lift capacity without any concern for machine list. Further, shear legs can be made much sturdier than any lattice boom of the derrick crane. Without any counterweight aboard, shear-leg cranes are more suitable to lift heavy weights than revolving lattice-boom cranes.

On an off-the-stern basis, shear-leg cranes are clearly superior to the fully revolving lattice-boom crane in terms of lift capabilities. Table 2 presents a comparison of the lift capacities of *Cappy Bisso* and those of a fully revolving derrick (e.g., the ringer-mounted Manitowoc 888).

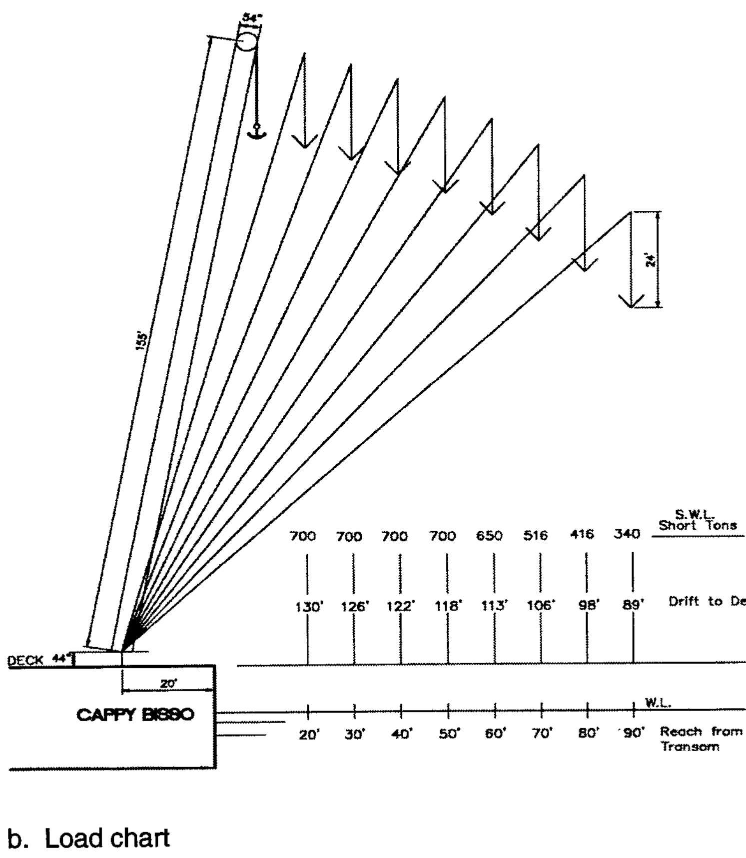
Consideration may be given to the use of tandem 700-ton derrick barges to handle up to 1,400 tons. This solution for the 700- to 1,400-ton lift range may be more desirable than committing to a single large piece of equipment capable of lifting an equivalent amount of weight.

Availability

There are shear-leg crane barges currently operating in inland waterways with lift capacities up to 800 tons. Shear-leg crane barges with up to 3,000-ton lift capacity are feasible for inland waterway construction. A shear-leg crane barge can be purchased in components and assembled onsite within approximately 6 to 12 months. Testing and obtaining operation certifications may require an additional 2 to 3 months.



a. Layout and dimensions



b. Load chart

Figure 22. *Cappy Bisso*

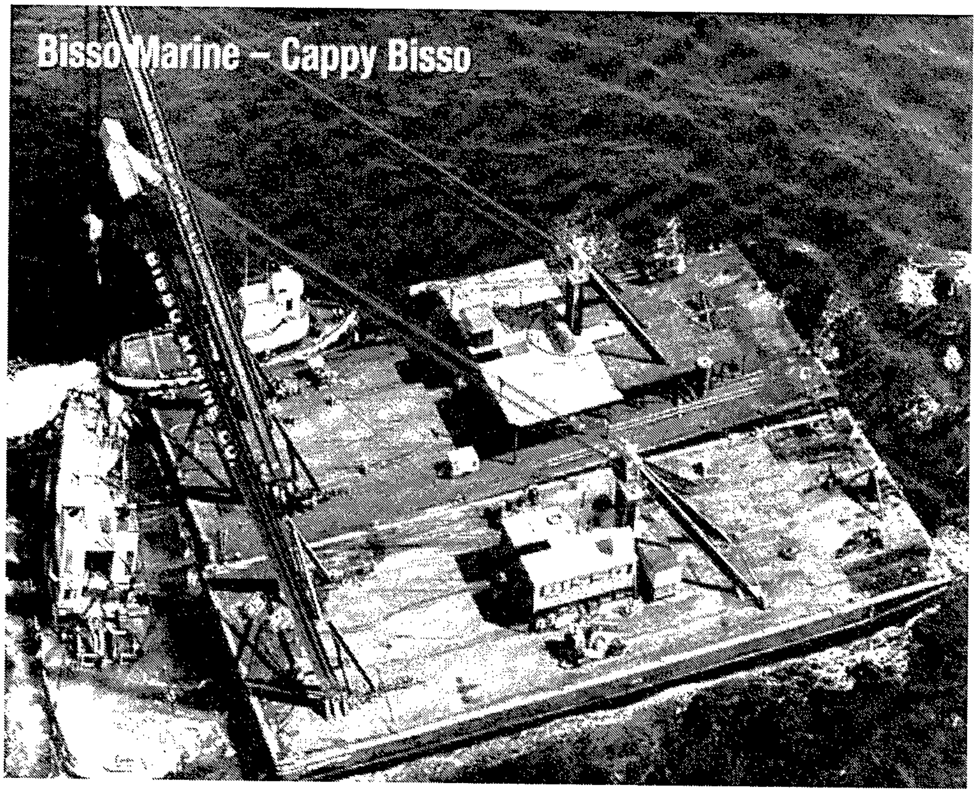


Figure 23. Twin shear-leg crane barges (*Cappy Bisso*) working together (lift capacity, each crane): 700 tons

Table 2
Comparison of Lift Capacities, Shear-Leg Crane Barges

Operating Radius ft (m)	Lift Capacity (tons) Directly Over Stern	
	Lift Capacity (tons) *Cappy Bisso*	Manitowoc 888
55 (17)	700	457
60 (18)	700	432
65 (20)	700	409
70 (21)	700	388
75 (23)	675	369
80 (24)	650	352
85 (26)	583	337
90 (27)	516	322
95 (29)	466	309
100 (30)	416	288
110 (34)	340	254

Alternatively, a suitable crane barge may be purchased from the existing inventory. Shear-leg barges with various sizes and capacities up to 700 tons are available within the United States (see Appendix B for reference materials). A-frame derrick barges require approximately 5 ft of river draft, allowing transport to any conceivable in-the-wet construction site. However, inland waterway projects will probably have height restrictions (such as bridges) that may preclude the use of larger A-frame crane barges. This evaluation must be performed on a case-by-case basis. The crane barge *Cappy Bisso*, for example, requires 45-ft headroom clearance in its access route.

Since the shear-leg crane barge is common lift equipment in inland waterways, it is likely that construction contractors can find suitable shear-leg barges near the construction site for leasing within a reasonable time window.

Mobility

A shear-leg crane can only raise and lower loads; it has no swing capability. Horizontal positioning of loads requires movement of the entire barge. The crane barges are not self-propelled, requiring towboats to position the barges. Thus, shear-leg barges are less versatile in handling loads, and its operations are slower than those of a derrick barge.

Economics

The salvage value of a shear-leg crane is less than that of a revolving crane. Although its first cost is relatively low, a large shear-leg crane barge may not provide the lowest total cost. At present, if a large shear-leg crane barge has to be assembled specifically for a project, the contract usually charges 30 to 50 percent depreciation cost to the project.

In general, the least-cost solution for providing hook service to a particular construction site is a function of equipment utilization rate, the duration of the project, and purchase versus lease decisions. In terms of the crane barge ownership, a contractor may either lease a crane barge or purchase a crane barge for the project, and salvage it after completion of the project.

Appendix B contains cost analyses of a 700-ton-capacity shear-leg crane barge (similar to *Cappy Bisso* in size and structure) in terms of three project cases. The first case assumes a 1-year project duration with 100 percent utilization of the equipment. The second and third cases assume 2- and 3-year project durations, respectively, with only 50 percent utilization of the equipment. For each case, both the buy-and-salvage option and the leasing option are evaluated.

It is assumed that the depreciation rate of the shear-leg crane is 40 percent. The lump sum depreciation of the barge is 20 percent of its initial cost. The cost of capital is assumed to be 8 percent, and the sales tax is 7 percent. The rental rate of a crane barge depends on the lease period. Crane rental companies usually

require a minimum lease period of 6 months. At present, the rental rate of *Cappy Bisso* is $15,000 per day for a 6-month lease.

The cost would increase to $4.3 million and $5.2 million for a 2- or 3-year project duration, respectively, assuming 50 percent equipment utilization. The analyses show that the cost with the buy-and-salvage approach will be approximately $3.7 million for a 1-year period with 100 percent equipment utilization.

For the leasing option, if the project requires lift-in operations within a work window over multiple years, it is much more economical to lease the crane for only the window period, and to mobilize and demobilize the crane barge before and after the window. The total cost will be approximately $3.2 million if the equipment is leased and operated for 1 year with 100 percent utilization. The cost will increase to $3.6 million and $5.4 million when leasing the equipment for 2 and 3 years, respectively, assuming 50 percent equipment utilization.

The analyses indicate that, if heavy-lift operations must be performed intermittently over an extended period, the purchasing option, as opposed to the leasing option, yields the most cost-effective solution based on various project duration and equipment utilization factors. As the cost-analysis example shows, the buy-and-salvage method gains significant financial advantage if the equipment works 6 months per year for a 3-year period.

If a project requires only a few very heavy lifts within a short period of time (between a few weeks and 3 to 4 months), leasing the lift equipment or subcontracting the lift work to a specialty company is a viable option and can be economical.

Offshore Crane Barges

Construction of offshore oil and gas platforms and storage facilities requires the transportation and onsite erection of very large prefabricated structures fitted with heavy equipment. Since the commencement of offshore oil exploration, offshore crane barges have been the workhorse of offshore construction. With increasing offshore activities in recent years, offshore crane barges have significantly increased in size and capacity and developed into so-called heavy-lift vessels (HLVs). Historically, decks weighing over 2,000 tons exceeded single crane lift capacities and were typically installed in multiple pieces. This led to high costs for offshore onsite hook-up and commissioning.

The development of HLV enables installation of a fully integrated platform deck in one single lift, with the inherent advantages of reduced cost, reduced cycle time, and earlier production. At present, the largest offshore derrick barge is fitted with two cranes, each rated at 6,500-ton capacity, for a total of 13,000 tons lifting capacity. Shear-leg barges with 5,000-ton lift capacity are not unusual.

The trend of using one single lift to install a fully integrated deck also promotes development of new lift-in techniques and technology. Two examples of innovations in offshore lift-in construction are the so-called "float-over" method and the Versatruss lift system. Practical cost-effective solutions developed by individual contractors eventually evolve into accepted industry practices. Since these two techniques may potentially have important applications for in-the-wet construction in the inland waterways, they are discussed separately in later sections of this report.

Besides performing heavy lifts, some HLVs are equipped to perform a wide range of tasks, such as dynamic station-keeping and underwater installation and retrieval. In deepwater or very congested areas where anchor moorings are difficult to lay, a HLV can accurately maintain its station with a dynamic positioning (DP) system referenced by seabed transponders, satellite positioning, or taut-line systems. Alternatively, the DP system can complement a reduced anchor spread. An integrated control system can be used to coordinate the two systems. These station-keeping systems allow the vessel to become a very stable platform for offshore operations.

The new generation of offshore crane barges enables the designers and contractors to develop cost-effective underwater construction techniques previously not possible. For example, the low vessel motions allow heavy submerged objects to be lowered and set down onto seabed foundation without the need for special motion compensators, and without causing large impact loads onto the foundation. Some vessels are also equipped with large-capacity subsea hoisting blocks, high-energy hydraulic underwater hammers, and deep dive systems.

Hydraulically operated lifting tools, rated up to 1,000 tons, can be remotely controlled either hydraulically or acoustically. These tools have been effectively used for deepwater installation or rigging retrieval operations without use of divers. For example, the foundation piles can be lifted using a remote-release lifting tool that requires no lugs or lifting attachment on the pile. They can then be stabbed into the template by the crane's underwater block, using remotely operated vehicles for monitoring. The underwater hammers can similarly be placed directly on the piles, driving them to their design penetrations.

In the offshore industry, every contractor operating or bidding for heavy-lift work has a unique approach and tries to develop an expertise around the capabilities of his equipment. Contractors have developed various specialties based upon their own strengths and weaknesses—shallow-water or deepwater projects; heavy, medium, or light lifts; new construction or marine salvage. As of 1999, there were at least 28 contractors with 82 heavy-lift vessels working in the Gulf of Mexico.

To provide an overview of the offshore lift construction in the United States, the offshore contractors specializing in shallow-water lift works and their equipment capabilities are highlighted below:

a. *Bisso Marine Company, Inc.* [PO Box 4113, New Orleans, LA 70178; phone (504) 866-6341] specializes in heavy-lift work in shallow water. The company owns several shear-leg crane barges (600- to 700-ton lift capacity at 40-ft working radius) and two revolving derrick barges (80- to 450-ton lift capacity at 40-ft working radius). These barges are all approximately 200 by 72 by 15 ft in size with an 8-ft minimum draft requirement (see Figures 22 and 23).

b. *Cardinal Services, Inc.* [3703 S. Lewis Street, New Iberia, LA; phone (318) 364-9704] owns three Amclyde 2000 shear-leg crane mounted on jack-up barges (100-ton lift capacity at 30-ft working radius). The barges are supported on legs and pads. They can work in water depths ranging from 8 to 145 ft.

c. *Cross Offshore Corporation* [1304 Engineers Road, Belle Chase, LA 70376; phone (504) 394-3506] owns a custom-built shear-leg crane barge (400-ton lift capacity at 40-ft working radius). The barge has a size of 195 by 68 by 12 ft with an 8-ft minimum draft requirement (see Figure 24).

d. *Danos & Curole Marine Contractors* [13083 Highway 308, Larose, LA 70373; phone (504) 693-3300] owns four jack-up liftboats (65- to 100-ton lift capacity at 30-ft radius). They can work in water depths ranging from 8 to 165 ft (see Figure 25).

e. *Global Industries, Inc.* [5151 San Felipe, Suite 900, Houston, TX 77056; phone (504) 868-9655] currently owns seven revolving derrick/lay barges with lift capacities ranging from 150 to 1,600 tons at 100-ft radius. These barges are approximately 400 by 100 by 25 ft in size with a 20-ft minimum draft requirement during lift operations (see Figure 26).

f. *Horizon Offshore Contractors, Inc.* [2500 City West Blvd, Suite 2200, Houston, TX 77042; phone (713) 361-2600] owns three revolving derrick barges (500- to 650-ton lift capacity at 70-ft radius). The barges are approximately 350 by 100 by 25 ft in size with 20-ft minimum draft requirement during lift operations (see Figure 27).

g. J. Ray McDermott, Inc. [801 North Eldridge Street, Houston, TX 77079; phone (281) 870-5000] provides multiple services in deepwater construction. The company owns a variety of heavy-lift vessels, including the largest revolving derrick barge DB 50 (3,500-ton lift capacity at 82-ft radius) and largest shear-leg crane barge SLC 5000 (5,000-ton lift capacity at 100-ft radius). These large crane barges generally do not meet the requirements for inland waterways construction, but can work along the coastal regions (see Figures 17 and 28).

h. *Laredo Construction, Inc.* [13385 Murphy Road, Stafford, TX 77477; phone (281) 499-4333] owns three shear-leg crane barges (350- to 600-ton lift capacity at 30-ft working radius). The crane barges are either supported by spuds or anchored by mooring systems (see Figure 29).

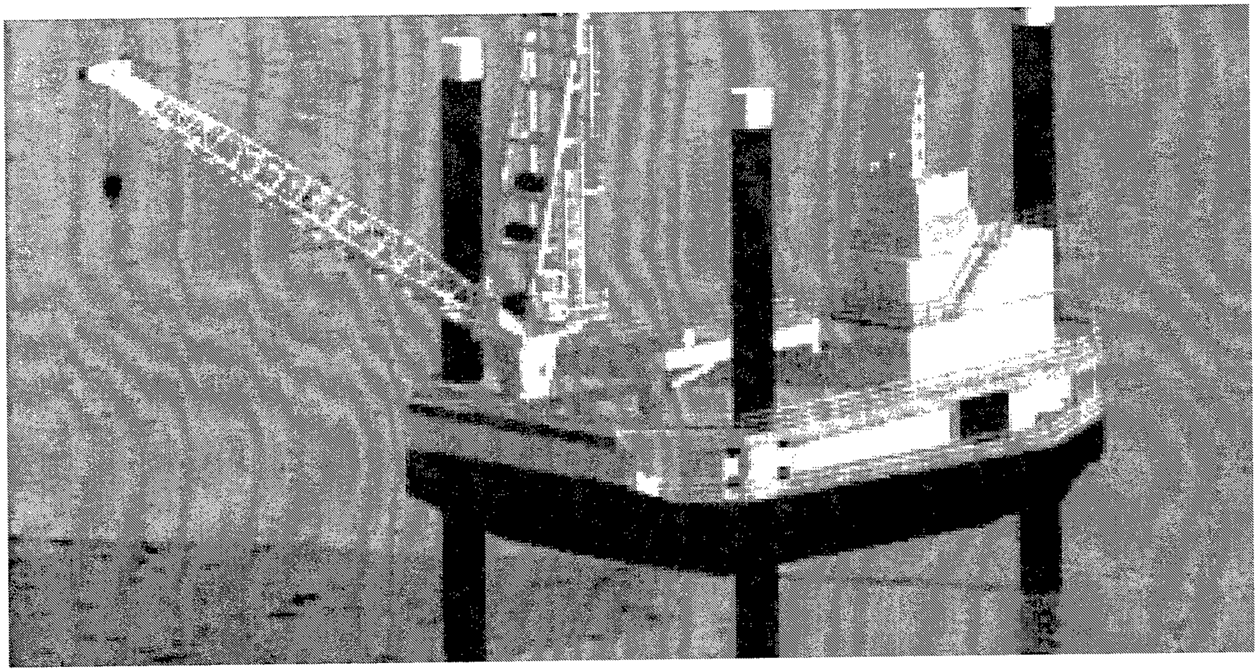


Figure 24. Shear-leg crane barge *Southern Hercules*. (Owner: Cross Offshore; lift capacity: 430 tons at 40-ft radius)

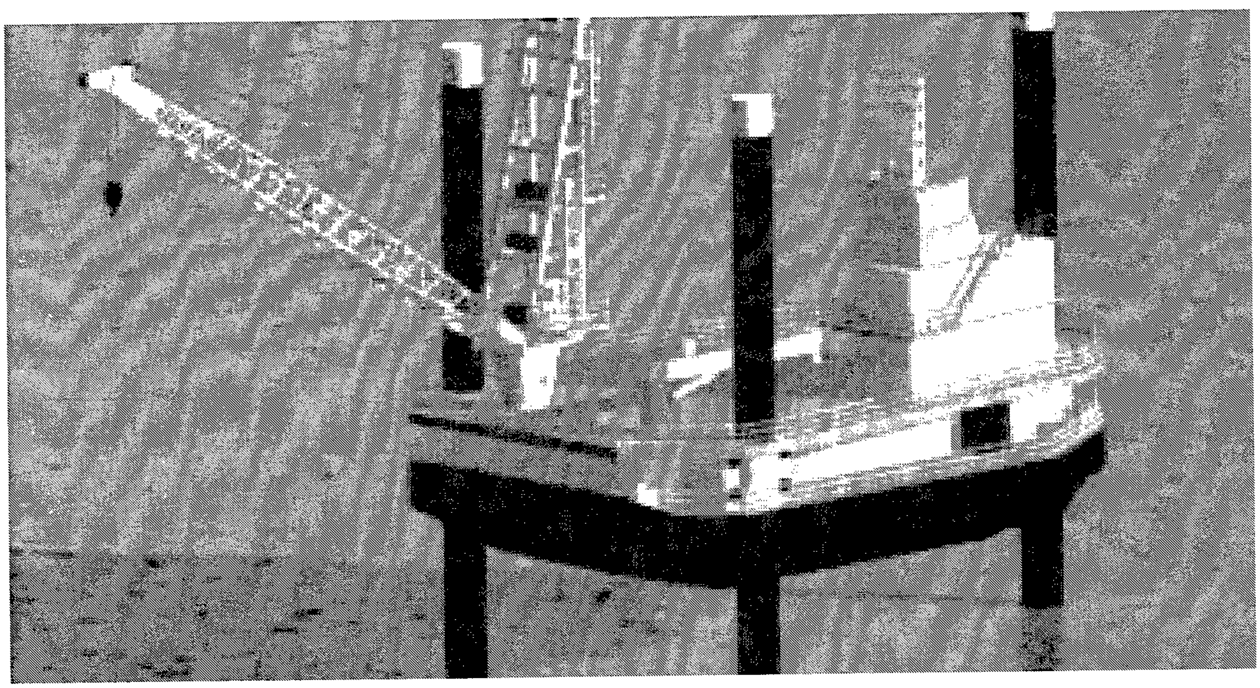


Figure 25. Revolving crane jack-up barge *David Luke*. (Owner: Danos & Curole; lift capacity: 100 tons at 30-ft radius)

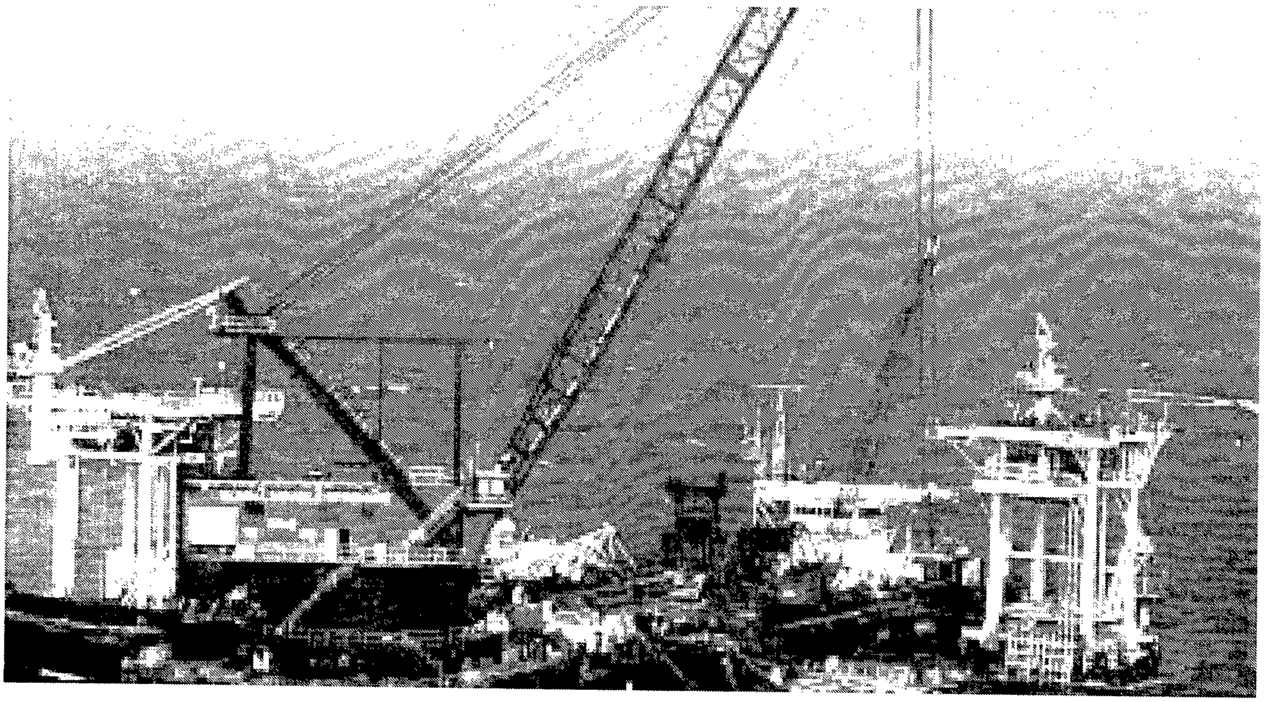


Figure 26. Revolving derrick barge *Arapaho*. (Owner: Global Industries; lift capacity: 650 tons at 70-ft radius)

Figure 27. Revolving derrick barge *Atlantic Horizon*. (Owner: Horizon Offshore; lift capacity: 500 tons at 70-ft radius)

i. *Manson Gulf, L.L.C.* [408 Bayou Dularge Road, Houma, LA 70363; phone (504) 580-1900] owns a heavy-lift revolving-derrick barge (420-ton lift capacity at 60-ft radius). The barge has dimensions of 299 by 90 by 20 ft and an 8-ft minimum draft limitation during lifting (see Figure 30).

j. *Offshore Specialty Fabricator, Inc.* [PO Box 1420, Houma, LA 70361; phone (504) 868-1438] has two heavy-lift derrick barges (600- to 700-ton lift capacity at 65-ft radius). The barges are approximately 350 by 100 by 25 ft in size and have an 8-ft minimum draft requirement during lifting (see Figure 31).

k. *Power Offshore Services* [PO Box 1717, Harvey, LA 70059; phone (504) 394-2900] owns four jack-up liftboats with lift capacities ranging between 75 and 350 tons at 30-ft radius. These barges are supported on spuds during lifting.

l. *Saipem, Inc.* [15950 Park Row, Houston, TX 77084; phone (281) 552-5700] owns several very large derrick barges for deepwater operations. Lift capacities range from 2,000 to 7,840 tons at 131-ft radius. These large crane barges generally do not meet the requirements for inland waterway construction, but can work along the coastal regions (see Figure 32).

m. *SVS Offshore* [5300 Memorial, Suite 550, Houston, TX 77007; phone (713) 426-1022] brought a shear-leg crane barge (the *Rambiz*) from Europe to the U.S. coast in 1999. It consists of two cranes mounted on a catamaran barge with a lift capacity of 3,000 tons at 90-ft radius. The *Rambiz* was originally built for a major bridge construction project in Portugal. It has since been modified and upgraded for offshore lift construction. The barge has a 20-ft minimum draft requirement (see Figure 33).

n. *Versatruss Americas, L.L.C.* [1112 Engineers Road, Belle Chase, LA 77037; phone (504) 392-0808] owns a multiple lift system on barges that can lift 20,000 tons in water as shallow as 5 ft (see Figure 34).

o. Smit Americas [400 E. North Belt, Suite 310, Houston, TX 77060] owns a series of shear-leg crane barges (Taklift series). The Taklift 8 is shown in Figure 35.

In the last several years, the majority of offshore contractors have been upgrading their heavy-lift vessels in anticipation of construction booms in the Gulf of Mexico. For example, J. Ray McDermott, Inc., has installed dynamic positioning (DP) equipment on its fleet. McDermott recently completed the conversion of the *DB 16* into a dynamically positioned vessel by adding four fixed, fully azimuthing thrusters along with an ABS Class II DP system with differential global positioning and accounting sensing capability. McDermott has also developed a deepwater lowering system suited for deepwater installation and recovery. The system includes a spreader bar, adapter box, and lowering tools to simplify transferring the load from the crane to the lowering system. Global

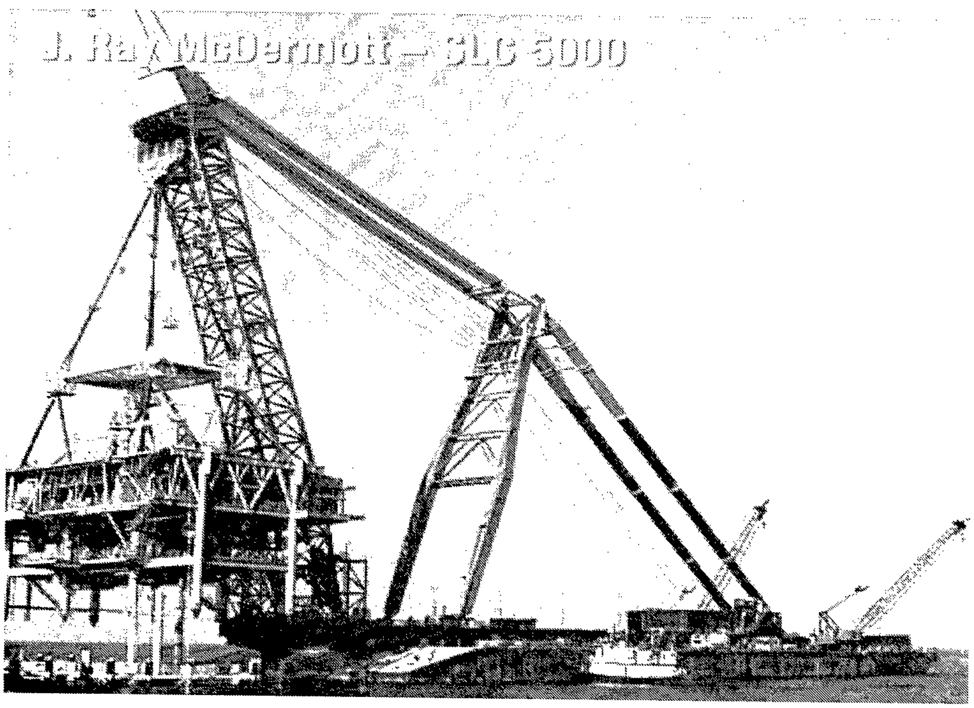


Figure 28. Shear-leg barge *SLC 5000*. (Owner: J. R. McDermott; lift capacity: 5,000 tons at 100-ft radius)

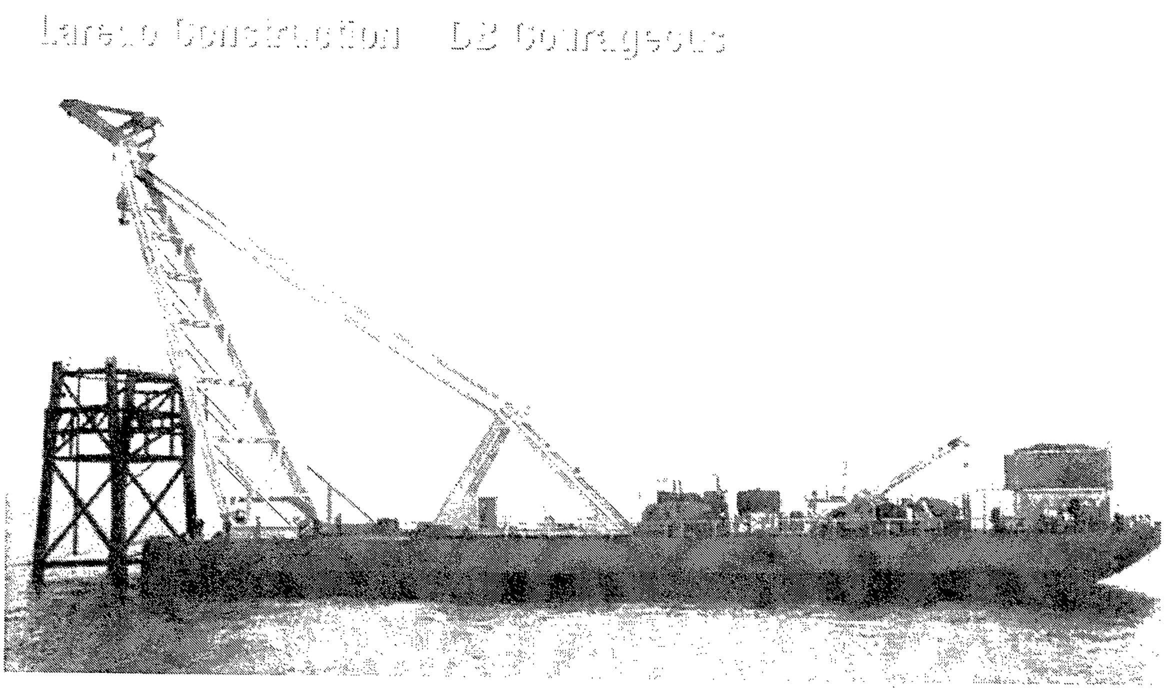


Figure 29. Shear-leg crane *DB Courageous*. (Owner: Laredo; lift capacity: 600 tons at 30-ft radius)

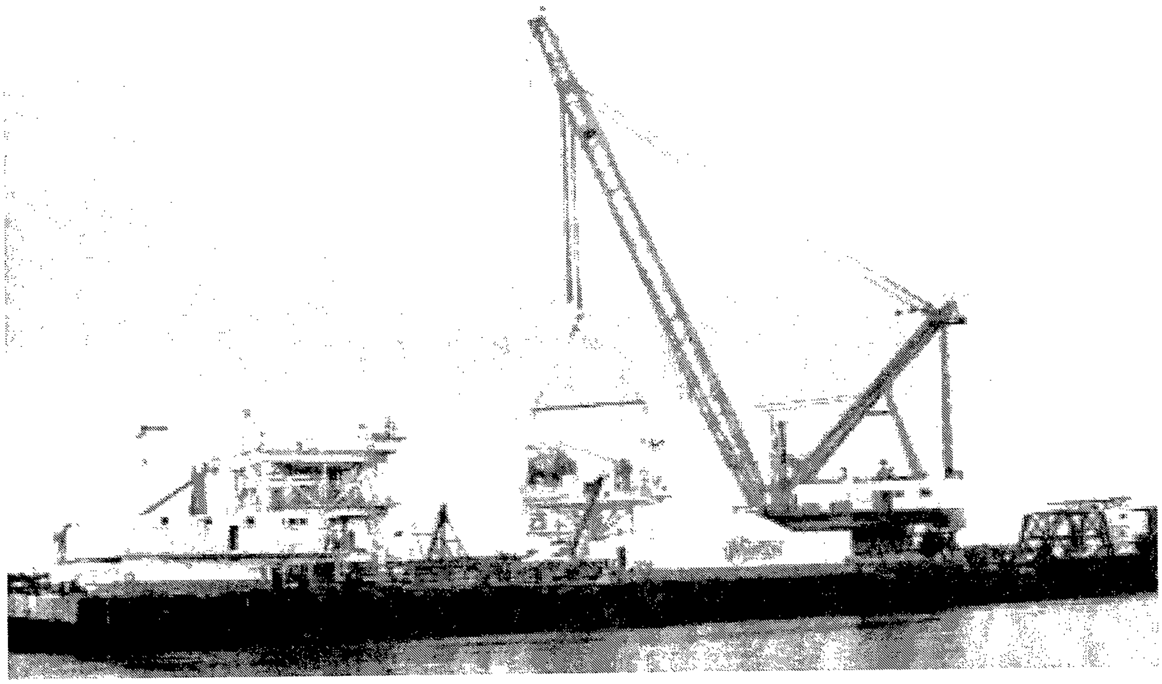


Figure 30. Revolving derrick barge *Wotan*. (Owner: Mason Gulf; lift capacity: 420 tons at 60-ft radius)

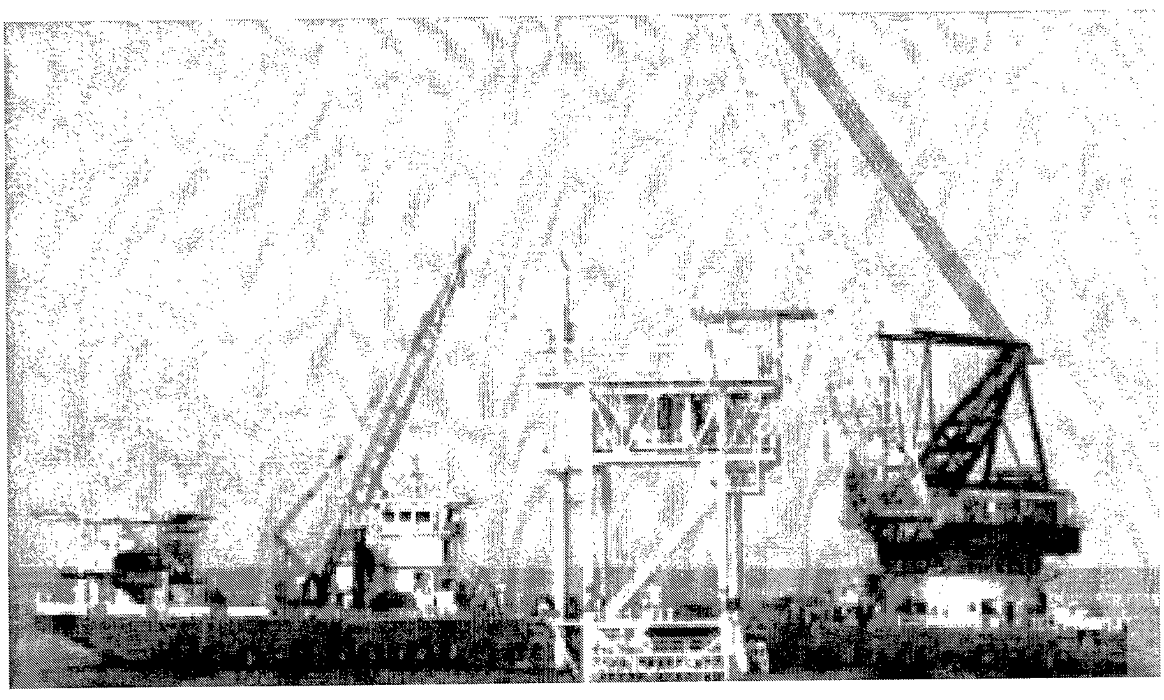


Figure 31. Revolving derrick barge *OFSI DB-1*. (Owner: Offshore Specialty Fabricators; lift capacity: 700 tons at 65-ft radius)

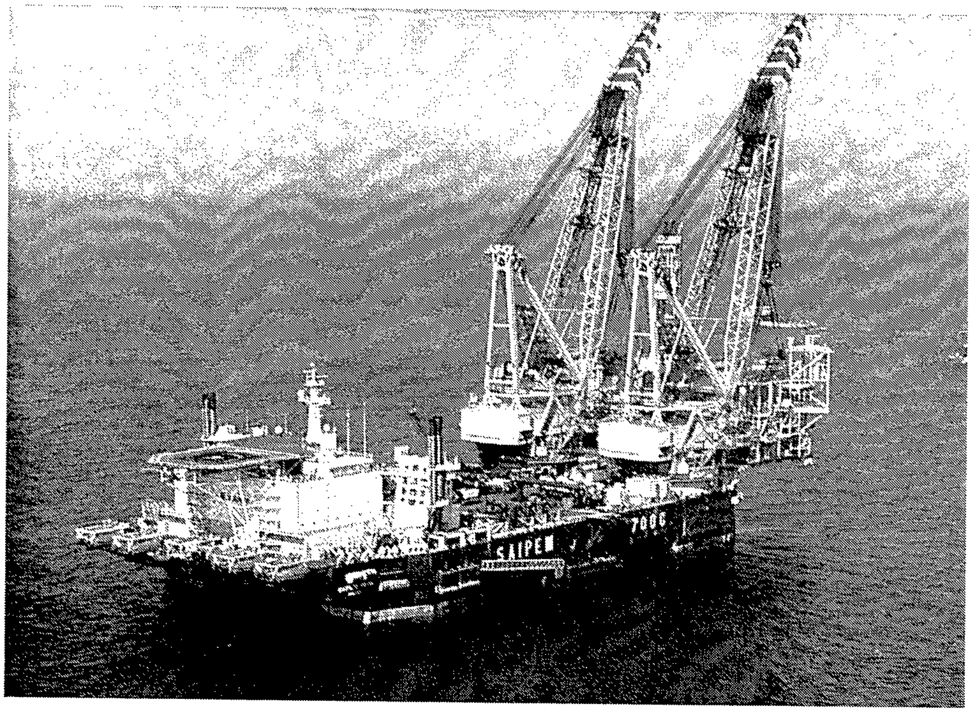


Figure 32. Revolving derrick barge *Saipem S-7000*. (Owner: Saipem; lift capacity: 7,840 tons at 131-ft radius)

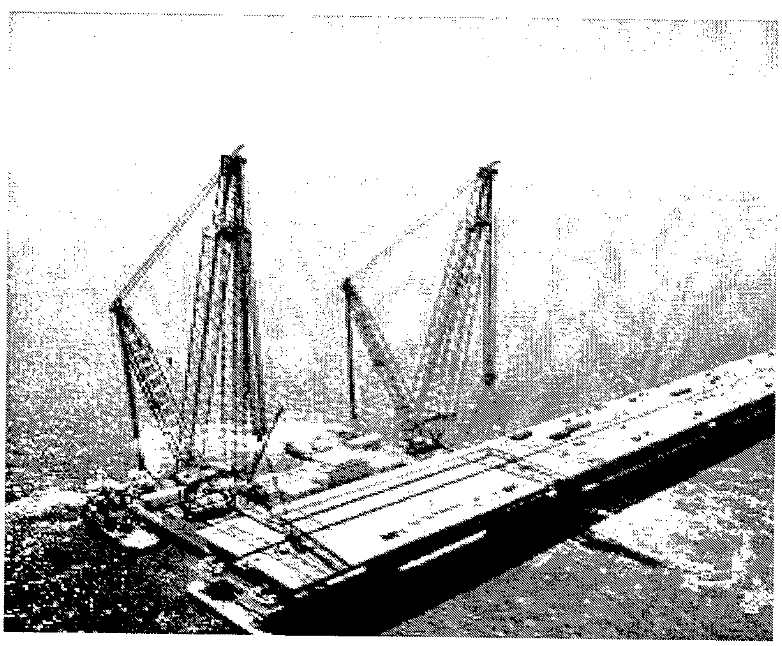


Figure 33. Catamaran crane barge *Rambiz*. (Owner: SVS Offshore; lift capacity: 3,000 tons at 90-ft radius)

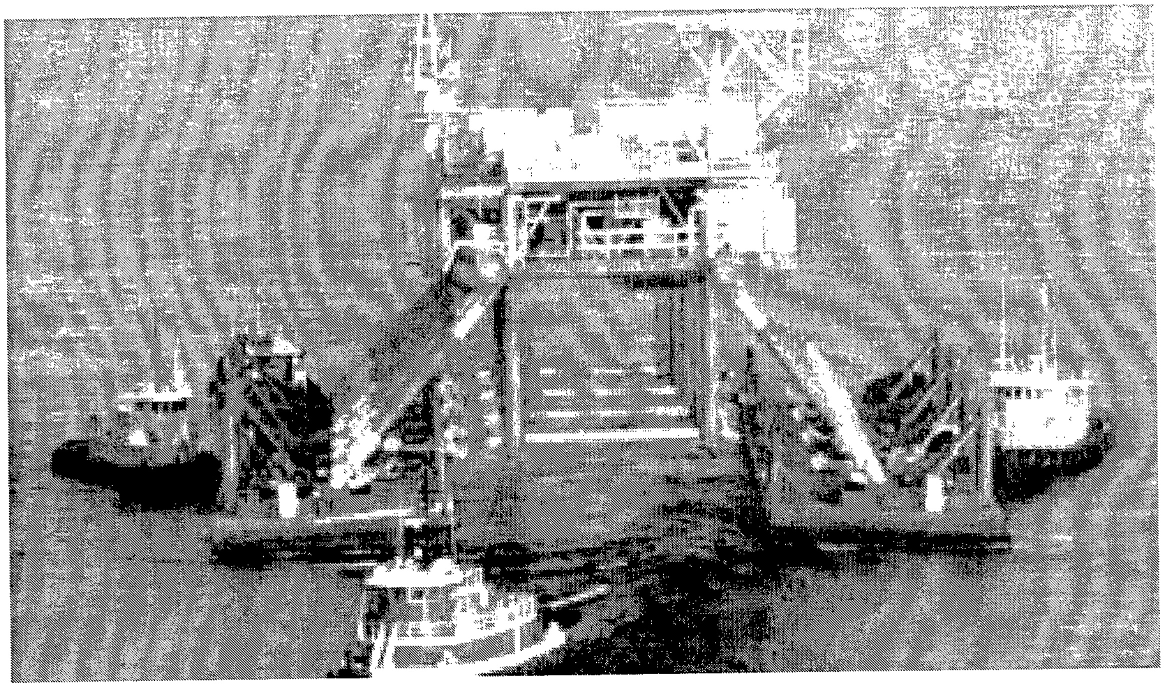


Figure 34. Versatruss lift system (Owner: Versatruss Americas; lift capacity: 20,000 tons)

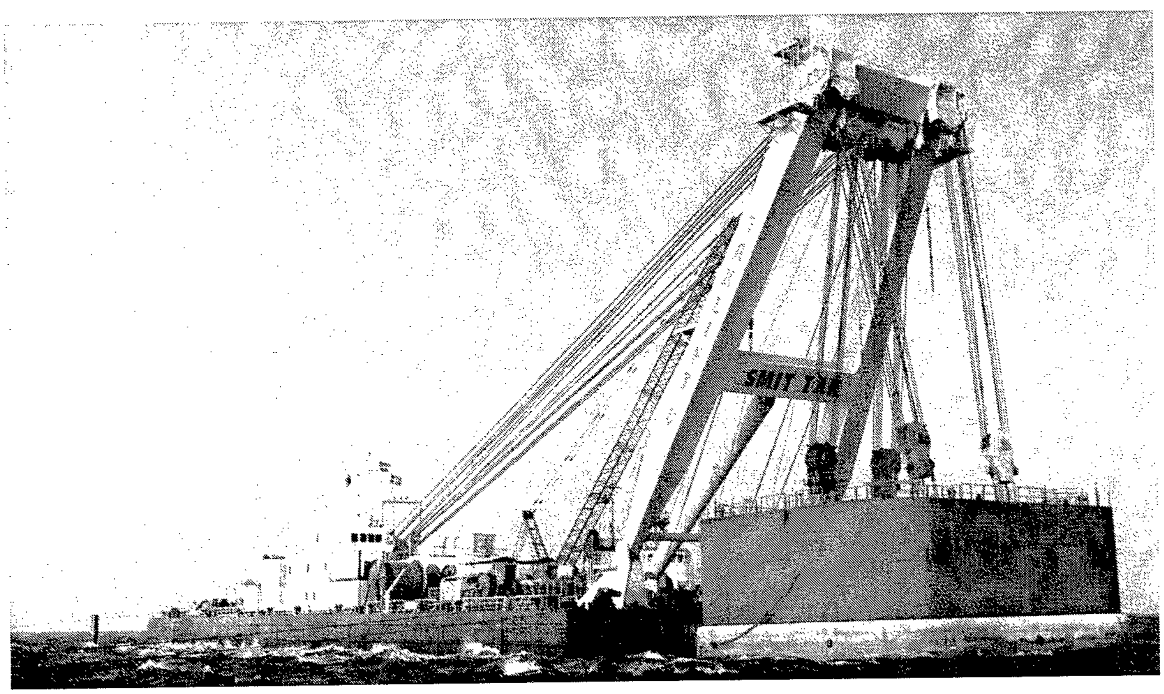


Figure 35. Shear-leg crane barge *Taklift 8*. (Owner: Smit Americas; lift capacity: 1,600-tons at 100-ft radius)

Industries, Inc., installed a DP system to the derrick barge *Hercules*. The vessel has six retractable, full azimuthing thrusters.

This section examines the availability and suitability of offshore crane barges for inland waterway construction. For the purpose of this study, we examine the Taklift series—a group of shear-leg crane barges made in Europe—as typical examples of offshore crane barges. Appendix C contains more detailed technical information on this equipment.

Capacity

Offshore crane barges are available in a wide range of lift capacities, ranging from 100 to 14,000 tons. Physical clearance restrictions will significantly limit the usefulness of the largest offshore cranes for inland waterways construction. These limitations include overall beam width, transport height, and draft requirements. Barge width is limited by the width of locks along the access route. (Barges wider than 108 ft will be precluded.) Transport height is limited by vertical clearances between the river surface and the bottom of bridges or powerlines along the access route. (Barges with heights exceeding safe bridge or powerline clearances will be precluded.) Draft requirements include the minimum water depth along the access route and at the construction site during lifting and setting loads. Table 3 presents a summary of Taklift equipment capacities and sizes.

Table 3
Lift Capacity of Taklift Equipment

Model No.	Lift Capacity (tons) at Distance (ft) Off Stern	Barge Length (ft)	Barge Width (ft)	Transport Height (ft)	Transport Draft (ft)
Taklift-3	400 @ 56	152	66	23	5.3
Taklift-1	800 @ 26	198	78	39	9.5
Taklift-6	1,200 @ 53	238	100	131	8.2
Taklift-4	1,600 @ 50	273	93	92	8.5
Taklift-8	3,000 @ 50	301	100	142	20.2
SLC 5000	5,000 @ 100	450	150	104	20.0

Note: To convert feet to meters, multiply by 0.3048.

Based on the capacities of the Taklift series equipment, it should be noted that shear-leg crane barges larger than 1,600 tons (the Taklift-4) will not pass through a typical lock. Furthermore, shear-leg crane barges larger than 800 tons (Taklift-1) will not clear smaller bridges typically encountered in inland water. The practical effect of these limitations is to exclude the Taklift-8 in all cases, and also the Taklift-6 and Taklift-4 if bridges are present along the project access route. Only the Taklift-3 and Taklift-1 are capable of physically accessing most inland waterway sites. Given the physical limitations described above, the Taklift crane barges generally have to be limited to an 800-ton lifting capacity for inland waterway projects. This capacity is comparable to the A-frame barges discussed previously, or two Manitowoc 888 cranes working in tandem.

In general, a large number of offshore crane barges meet the physical restrictions for inland waterways work. These cranes usually are rated up to 800 tons. If the crane capacities exceed approximately 800 tons, larger barges are required to provide lifting stability offshore. As a result, these large crane barges generally do not meet the inland waterways access requirements.

Availability

Since the late 1980s there has been an oversupply of deepwater heavy-lift vessels in the Gulf of Mexico. These vessels have experienced utilization rates of less than 50 percent. However, offshore deepwater vessels with both lift and pipelaying capacity are in high demand because of the need for equipment to lay the deepwater pipelines. These lift/lay derrick barges are usually booked at least 2 years in advance to ensure their availability for specific projects that are designed around the capacity of the contractor's equipment.

The offshore shallow-water lift construction has been very active, with contractors having several months of backlog. Thus, the market for shallow-water lift equipment has been very fluid, and the equipment availability for any specific period of time generally cannot be guaranteed in advance without a contract. Nevertheless, because of a large number of existing offshore cranes and seasonality of offshore construction, it is reasonable to expect that a general contractor has a good chance to lease a suitable offshore crane for several weeks to several months.

In leasing an offshore crane barge for a short period of time, mobilization and demobilization could become a significant portion of the rental cost. Therefore, projects have to be a certain scale and value for an offshore crane barge to be competitive for inland waterways works.

The Jones Act, passed by Congress in 1920, limits the types of vessels that may transport goods on inland waterways in the United States. In particular, this act requires vessels performing such services to be built in the United States, operated by U.S. crew members, and owned by U.S. citizens. "Transporting goods" is strictly interpreted to mean that the vessel may not move from the point of lift. This definition would effectively preclude the use of any foreign vessels, such as the Taklift cranes, from transporting prefabricated modules in the U.S. inland waterways. However, the lifting operation of these vessels is permitted and would be practical if a transport barge delivers prefabricated modules to a pre-positioned crane barge.

Mobility

Offshore crane barges consists of various types and sizes. Derrick barges are normally self propelled and offer the best mobility and versatility. Shear-leg barges, jack-up barges, and catamarans are typically not self propelled and will require a support tug(s) for transport. Offshore crane barges generally have similar

characteristics of the same type of crane barges used in inland rivers. These characteristics are discussed in other sections of this report.

Economics

The existing offshore crane barges are generally leased at varying rental rates, depending on the required work window, the offshore construction market, and seasonality. A general contractor bidding on inland waterways construction normally faces the option of assembling a custom-built crane barge and forming a joint venture with (or subcontracting to) a suitable offshore contractor. In general, teaming with or subcontracting to an offshore contractor can be economical, if heavy lifts will be performed in a short period of time (i.e., several weeks to 2 months) for offshore construction reasons. However, if heavy lifts must be performed intermittently over an extended period, onsite assembly of a custom-built crane barge appears to be cost effective.

As an example, cost analyses are performed of the Taklift 8, which is currently working in U.S. coastal waters and may be leased through Smit International, Inc., of Houston, TX. The 3,000-ton crane barge currently leases for $30,000 per calendar day, with no minimum rental period. This cost does not include operating crew (on the order of $3,000 per shift), tugs or push boats, support equipment, and other operating expenses. Total actual lease and operating costs are approximately $40,000 per calendar day, or $13.8 million for a 1-year project with a 100 percent utilization factor. This cost is significantly higher than alternative methods, such as a catamaran barge equipped with hydraulic jacks.

Appendix C also contains a cost comparison between leasing a 2,000-ton shear-leg crane barge or constructing one. Total construction cost would be approximately $13.6 million, including a new hull, support systems, and shear-leg crane. The analysis indicates that a 1-year project with 100 percent equipment utilization will have a total cost of $6 million if the equipment is constructed for the project, compared with $9.4 million if the equipment is leased. If the project lasts 2 years with 50 percent equipment utilization, the costs will be $7.9 million for the purchase option and $10.1 million for the leasing option. For a 3-year project with 50 percent equipment utilization per year, the cost for purchasing and leasing would be $10.3 and $15.1 million, respectively

Jack-up Crane Barges

A jack-up barge is usually towed or pushed to the construction site, moored with a spread mooring, and then jacked free of water. Thus, jack-up barges provide a stable work platform capable of supporting conventional, land-based heavy-lifting equipment. Stability is provided by spuds (vertical support piles) pushed or driven into the riverbed. The barge can mechanically "climb" on the spud piles and firmly lock itself to the supporting legs (see Figure 36).

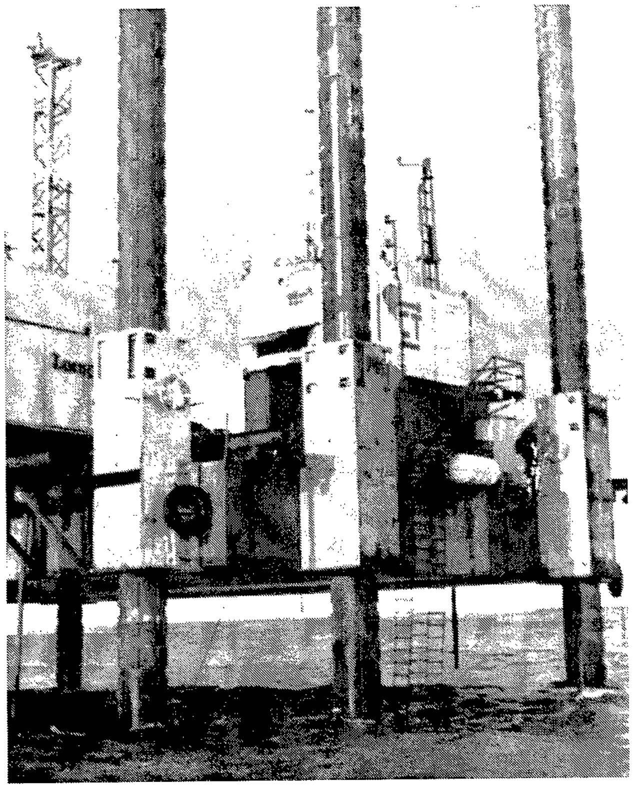


Figure 36. Jack-up barge climbs on spuds

Jack-up barges have proven to be very effective heavy-lift equipment in turbulent water or swift current. Where a large number of operations must be carried out at one location, a jack-up crane barge can be especially valuable.

Due to its inherent stability, the jack-up can barge can place lifted objects below or over water to a much tighter positioning tolerance than other types of floating cranes. Also, lift capacities of cranes mounted on jack-up barges are rated about 50 percent higher than those of floating cranes. Some large jack-up cranes can accommodate heavy lifts exceeding 2,500 tons out 60 ft from the stern of the barge.

Jack-up platforms are also ideal to perform some other overwater construction activities, such as screeding the foundation site and grinding a rock foundation for seating of precast concrete foundation segments.

Jack-up crane barges are usually outfitted with four to eight legs, built either of tubular or latticed steel. Spud piles, and the related barge-pile connections, are designed to adequately support the weight of the barge, lifting equipment, and maximum lift weights. Under normal circumstances, spud piles penetrate the riverbed or seafloor under their own weight. In some soils, pile penetration can be aided by jetting and vibration. The jacking system that is built into the leg supports can also be used to force the spuds into the soil. To a great extent, lift capacity is dependent upon the soil bearing capacity. It is essential that soil bearing capacity be verified to ensure acceptable levels of pile settlements. Of

particular concern are layered soils, in which a spud may gain temporary support but yield suddenly under heavy loads. Grouting may sometimes be required to enhance soil capacity.

A new development is to place mats onto the bottom of the spuds, so that once the spuds are jacked down, the barge primarily rests on mat foundations over the riverbed or seafloor. A short stub spud penetrates through the mats into soil to resist lateral forces.

Figure 37 illustrates installation of an offshore platform by a 4,000-ton jack-up crane barge. Figure 38 shows a typical lifting operation of a jack-up barge during installation of a caisson of the Second Severn Bridge in England. The barge shown is the *Lisa A*; the twin cranes are Lampson Transi-Lift Series III A. Appendix D contains technical information of the Lampson cranes and cost analyses for this type of heavy-lift equipment.

For the purposes of this study, the *Lisa A* is evaluated as a typical jack-up barge for inland waterway uses. The *Lisa A* was originally designed and built to support the construction of a nuclear power station by Guy F. Atkinson & Company in 1977. In 1985, the barge was improved with new legs and modified jacking system for Middle East works. In 1992, the vessel was purchased to carry out heavy lifting at the Second Severn Bridge project. The operations of the crane barge included lifting and positioning of up to 2,000-ton precast concrete caissons, pylon cross beams, and deck elements.

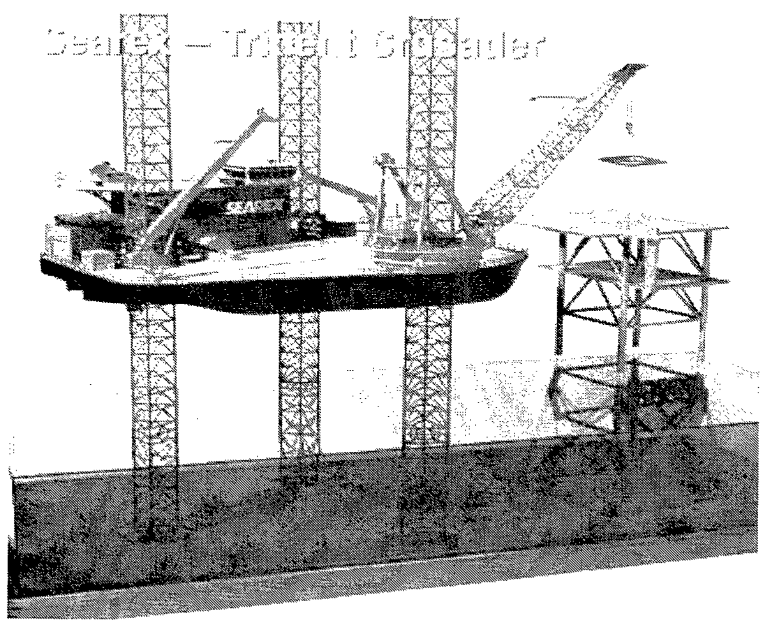
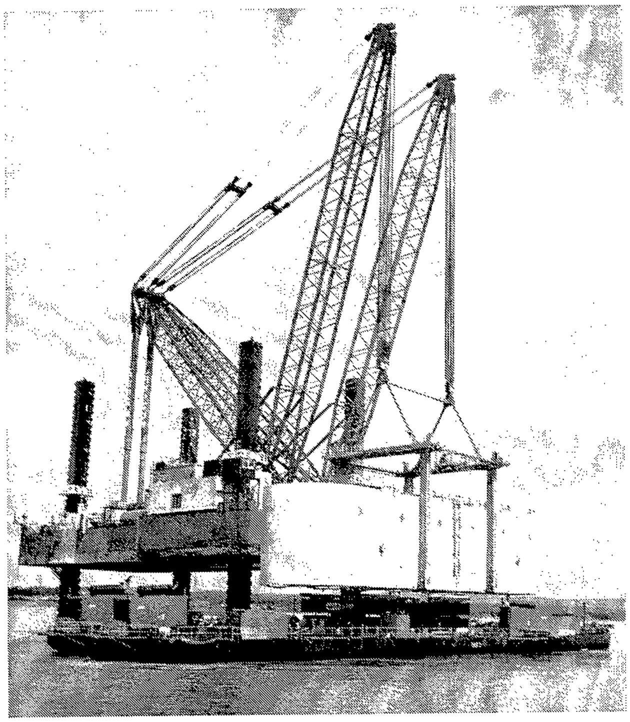
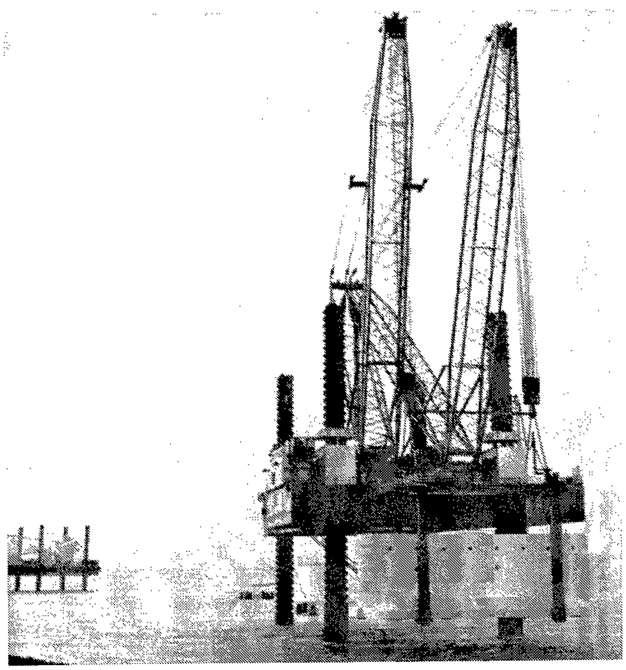


Figure 37. Offshore jack-up barge used to install a topside



a. Lifting a bridge caisson off a transport barge



b. Lowering a bridge caisson into water

Figure 38. Two Transi-Lift cranes on *LISA A* during lifting and lowering of a bridge caisson

As a part of the modifications, sponsons were added to the hulls, and a lifting system with two Lampson cranes was installed with subsequent modification to barge structures to withstand the design loads. Furthermore, a grouting plant was placed on the barge for the purpose of grouting caissons.

Figure 39 shows the general dimensions and layout of the barge. Components of the *Lisa A* include the following:

a. *Hull.* A T-shaped self-elevating platform. A large recess is formed in the central part. All internal compartments are free of equipment. They are either void spaces or ballast tanks. The barge is equipped with four legs, each fitted with a quadruple tooth and bar jacking system.

b. *Spuds.* Legs are rectangular tubes, made of high-strength steel plates. The lower end of each fore leg is fitted with a socket that allows a better load distribution on soil. There is no socket fitted on aft legs.

c. *Mooring winches.* Eight identical winches are located on-deck (four on fore end and four on aft end). Each winch is equipped with a mooring line passing through a fair-lead on deck. They are powered by two independent hydraulic power packs, one serving the four fore winches and the other the four aft winches. The winches can be used in four ways:

(1) One winch at a time (one winch under control with no influence of the other winches).

(2) Four winches paying in and four paying out (barge movement under control).

(3) Eight winches paying out (all winches paying out under a controlled load).

(4) Eight winches paying in with load and speed control (winches controlled under preset values, movement will stop if values are reached).

d. *Docking rails.* The self-elevating platform can be moved by a pushing boat. Interface between *Lisa A* and pushing boat is made by docking rails installed port and starboard at 20-m on centers.

e. *Towing points.* The *Lisa A* can be towed to or from the site using a towing bridle fixed to two Smit brackets located aft of the deck. The safe working load of each Smit bracket is 50 tons.

f. *Transi-Lift cranes.* Two Lampson Transi-Lift cranes are supported on transverse beams located in the hull, one between fore legs and the other between aft legs. The main boom uses pin connections. The mast takes compressive loads from the main boom, lowers tension in the topping lift by reducing the angle, and completely eliminates compression in the stinger. The stinger serves as a base for the winches and support area for the control cabs. The main boom, mast, and stinger are attached to front tubs located on fore transverse beam.

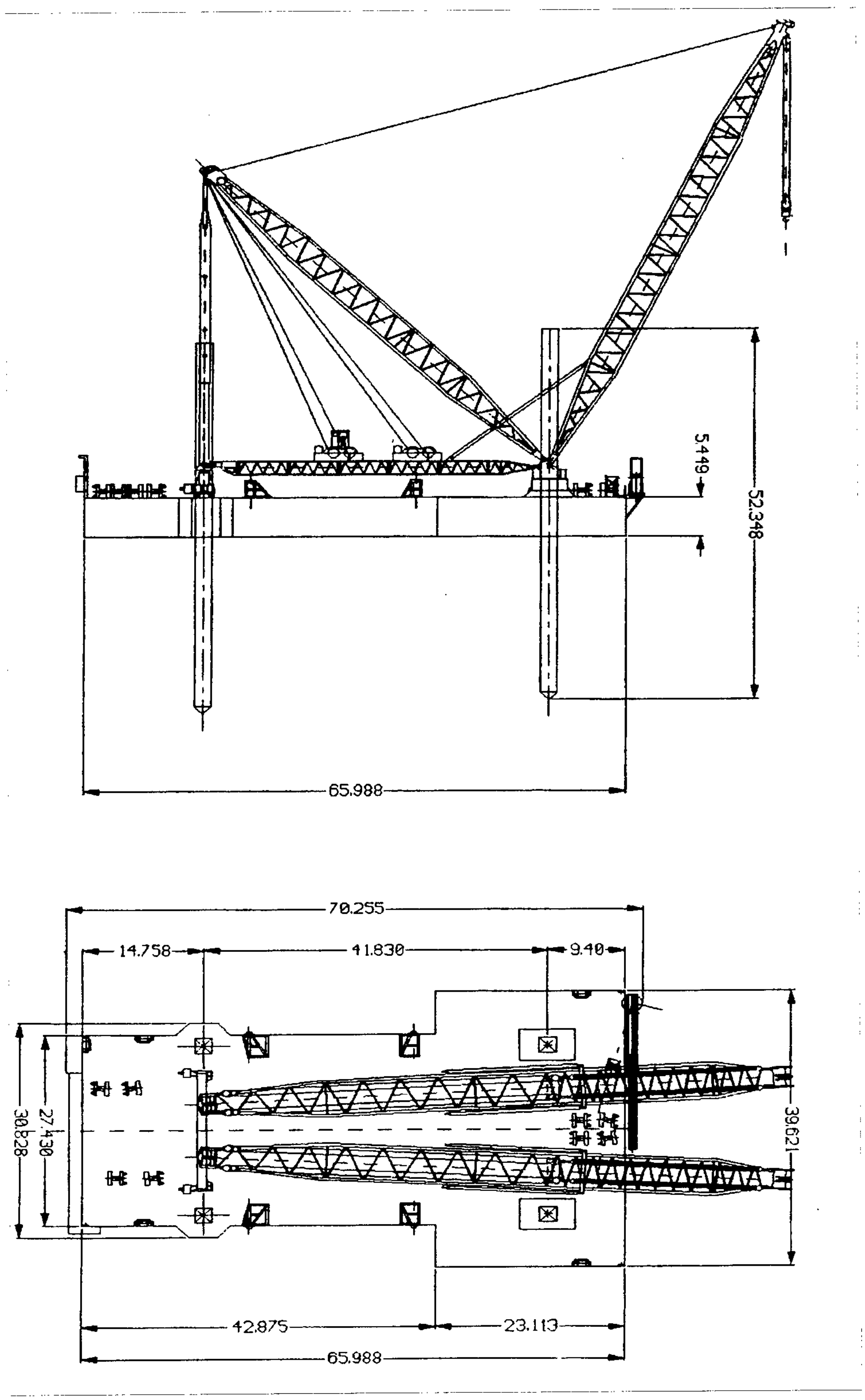


Figure 39. *Lisa A* jack-up crane barge (dimensions and layout)

g. *Engine house and control room.* These are located on the starboard sponson and contain a diesel generator for utilities and the hydraulic unit of the jacking system. The control room contains the central control panel for operation of all jacking units and emergency shutdown switches.

h. *Surveyor's cabin and heavy-lift control cabin.* These are located on the starboard sponson.

Capacity

Due to the inherent stability of jack-up barge platforms, the lift capacity of cranes mounted on jack-up barges is usually rated about 50 percent higher than that on floating cranes. Under many circumstances, the lift capacity of a jack-up crane barge is determined by the bearing capacity of the spud piles and strength of the barge platform, as well as the lifting equipment mounted on the barge. The *Lisa A* barge, as previously described and used for the Second Severn Bridge project in England, was equipped with two LTL-1500 Transi-Lift cranes, manufactured by the Neil F. Lampson Company, Kennewick, WA (with 220 ft of boom and 190 ft of mast). Table 4 outlines the lift capacities of these cranes.

Table 4
Lift Capacities of Single and Tandem Transi-Lift Cranes

Operating Radius, ft (m)	Lift Capacity of Single LTL-1500 Transi-Lift Crane (11-deg swing), tons	Lift Capacity of Tandem LTL-1500 Transi-Lift Cranes (11-deg swing), tons
45 (14)	1,389	2,500
50 (15)	1,389	2,500
55 (17)	1,389	2,500
60 (18)	1,389	2,500
65 (20)	1,389	2,500
70 (21)	1,380	2,483
75 (23)	1,280	2,304
80 (24)	1,194	2,148
85 (26)	1,117	2,010
90 (27)	1,049	1,887
95 (29)	988	1,778
100 (30)	933	1,679

In the above calculations, the tandem capacity of the two LTL-1500 cranes is taken as 90 percent of twice the single-crane capacity. Each machine has approximately 11 deg of swing in either direction. The center of rotation of the crane for this jack-up barge is approximately 21 in. from the stern. This heavy-lift arrangement is capable of picking approximately 2,148 tons 60 ft from the stern of the jack-up barge. Deck-mounted Transi-Lifts have no counterweights; the barge itself is the back-anchor. Lift capacity can be increased to 2,350 tons by installing LTL-2600 cranes in lieu of the LTL-1500s on the *Lisa A*.

Availability

LTL-1500 Transi-Lift cranes are available with approximately 6 months lead-time for either purchase or lease. It will likely take an additional 3 to 4 months to assemble the crane barge and obtain certification. Most lift equipment rental companies will lease the required cranes on a minimum 6-month rental period. Standby rent will be approximately at 50 percent of the full-use rental rate.

Jack-up barges are available in various sizes and capacities. For example, the *Lisa A* is currently idle and is available for either lease or purchase. However, this market is global in nature; the cost and availability must be determined at the time of actual equipment need.

Mobility

A jack-up crane barge performs very effectively when many lifts have to be carried out at one location, because barge relocation is one of the most difficult operations. To relocate a jack-up barge, the mooring lines are first reattached and tightened. Then, the barge is jacked down until it is afloat. The spud piles are jacked free, one at a time. If spuds cannot be easily pulled out, jetting is used to assist the jacking operation. In clays, low-pressure water injection is more useful than high-pressure jetting. In no event should an attempt be made to free the legs by lateral working of the barge. Lateral forces can result in a bent or jammed leg with very serious consequences.

In one case in Cook Inlet, Alaska, a spud leg was jammed by the high current pushing on the barge side during its relocation operation. Then the tide rose over 6 m, flooding out the jack-up barge. Statistical studies of past construction accidents show that jack-up barges are approximately six times more likely to incur serious damage during relocation and transit than they are in jack-up position during lift operations, primarily due to the high center of gravity and, correspondingly, decreased stability with spud piles up.

Once the barge moves to a new location for the next lift, it is moored with a spread mooring. Then the legs are lowered to the riverbed and allowed to penetrate under their own weight. In some soils, penetration can be aided by jetting vibration. Using the jacks on one leg at a time, the barge acts as the reaction and the legs are forced into the soil. With all legs well embedded, the barge is jacked up clear of the water and raised up to its working height. Then the legs can be cut loose, one at a time, and a pile hammer is used to gain even greater penetration. Since uneven settlements may take place as a result of time, lift operations, and current input into the legs, the jacks have to be periodically reactivated to equalize the load on each leg.

Jack-up barges normally require a 5- to 7-ft minimum draft and work in water depths up to 60 m (200 ft). Thus, the barge can travel to, and work in, almost all the inland waterways construction sites. During transportation, the legs may be removed from their upward position and later reattached at the site.

Economics

Appendix D includes detailed cost analyses of a jack-up barge similar to the *Lisa A*, over which twin LTL-1500 Transi-Lift cranes are mounted. At present, LTL-1500 Transi-Lift cranes can be purchased for approximately \$8 to \$9 million each (new), and the Lisa A can be purchased for between \$4 and \$5 million. Total cost to purchase and assemble all necessary equipment will be in the range of \$22 to \$25 million. Because the salvage value of such a jack-up barge is not high, contractors usually have to take 30 to 50 percent write-off cost for the barge. However, the Transi-Lift cranes have high salvage value. The depreciation of the Transi-Lift cranes is about 5 percent of the initial cost.

For the buy-and-salvage method, a 1-year construction with 100 percent equipment utilization will cost approximately \$7.8 million (including ownership, mobilization, and operating costs). These costs increase to \$9.7 million if the same work is spread over two seasons. Finally, the cost for 3 years of heavy lift and 50 percent equipment utilization is approximately \$12.1 million.

For the leasing option, the jack-up crane barge will cost approximately \$10 million for a 1-year lease with 100 percent utilization. Cost will increase to \$10.9 million for a 2-year operation with 50 percent utilization. Finally, leasing the crane barge for a 3-year project with 50 percent utilization each year will cost approximate \$15 million.

If a project requires only a few heavy lifts within a short period of time (a few days to a month), leasing the lift equipment or subcontracting the lift work to a specialty company may be economically sensible.

If a long-term project requires intermittent uses of a jack-up crane barge over an extended period of time, it appears more economical to purchase the cranes and salvage them at completion of the project than to enter into multiple lease agreements.

Catamaran Barges with Lifting Beams or Gantries

All of the methods discussed previously rely on some form of a lifting mechanism equipped with either a lattice boom or shear-leg frame for hoisting a load using a wire rope and load blocks. The load is located some distance from the lifting mechanism's centroid, and the resulting eccentricity creates an inherent upper limit on the load that can be practically lifted. Twin barges, working in unison with hydraulic lifting equipment, offer an alternative means of lifting heavy objects. This lifting mechanism of a catamaran barge avoids the limitations created by eccentrically lifting heavy loads.

For heavy lifts in rivers and harbors, especially for placing submerged prefabricated modules, catamaran barges are frequently employed. Catamarans consists of two long barge hulls (pontoons), spread apart, and joined over the top

by cross beams (plate girders, trusses, or gantries). The cross beams are installed at one or both ends of the pontoons in order to resist fore-and-aft differential movement of the tow pontoons. Lifting devices are often arranged on the cross beams.

For inland waterway construction, catamaran barges have several advantages:

a. Catamaran barges are usually custom-designed to lift loads for specific projects. This offers unique advantages in load-handling, positioning, stability, and economy.

b. There is no system eccentricity, since the hydraulic cylinders are mounted symmetrically about the load. Catamarans therefore do not tend to list or trim during lifting and setting loads. Among all the floating cranes, catamarans offer the greatest floating stability during installation of prefabricated modules. For the same reason, catamarans have much higher lift capacity than other types of cranes for a given winch power.

c. Heavy lifts are possible from relatively inexpensive hydraulic equipment.

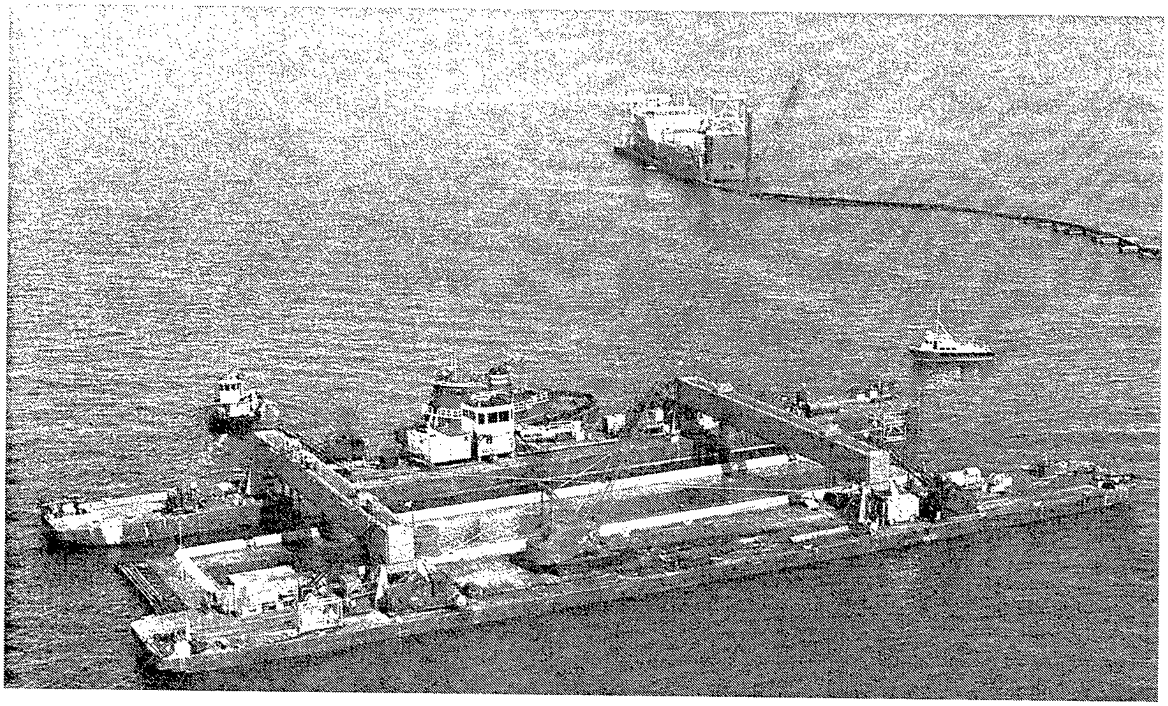
d. Equipment components are custom designed and easily assembled at the site, eliminating physical clearance conflicts during transport.

e. Hydraulic lift equipment usually provides smooth operations and reliable control.

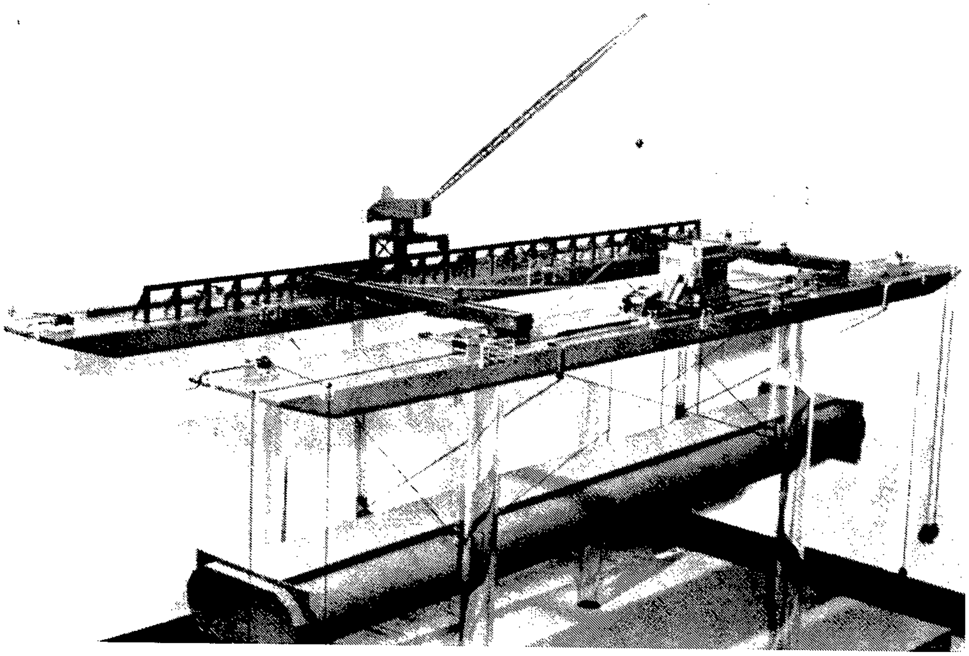
f. River contractors are more familiar with catamarans than any other crane barges.

To meet the versatility requirements, various types of catamarans have been built in the past for heavy lifts over water. A common and economical type of catamaran is the use of two floating barges connected by large plate girders or heavy trusses. The girders or trusses are designed to accommodate multipart lifting blocks located along the girder. The resulting catamaran crane barge straddles the load, and the load blocks are used to lift and lower the load with a series of prestressing tendons or rods. This assembly is towed or pushed into proper position, and the load is placed using hydraulic winches. Figure 40 shows a typical catamaran of the type carrying a segment of an immersed tube (the Hampton Road Immersed Tunnel).

A very powerful and versatile type of catamaran is a twin-hull barge connected with fixed hammerhead gantry cranes. The hammerhead provides substantial flexibility for the cranes to lift and place large and heavy loads above and below water level. An example of this type of catamaran is a European-manufactured heavy-lift vessel, the *Svanen*. The *Svanen* is a 103- by 72- by 102-m-high catamaran with an 8,200-ton lift capacity. Its plan and elevation are shown in Figure 41. The hammerhead on the gantry provides substantial flexibility for the cranes to lift and place large objects either underwater or at 80 m (262 ft) above the water surface. Using eight appurtenant windlasses, the equipment can achieve a positioning accuracy of 20 mm.

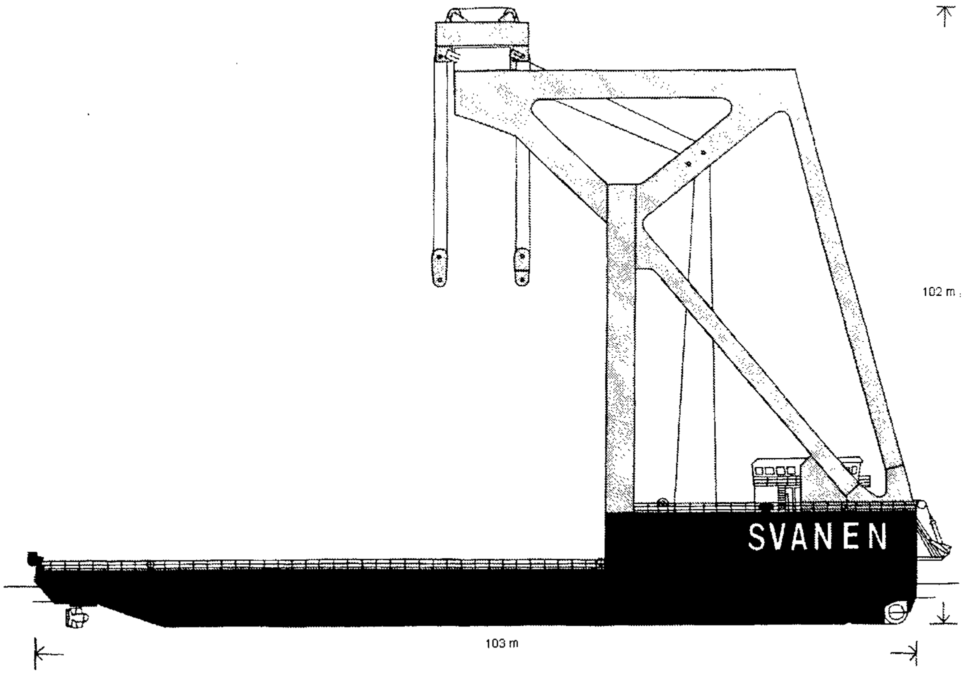


a. Catamaran carrying an immersed tube tunnel section

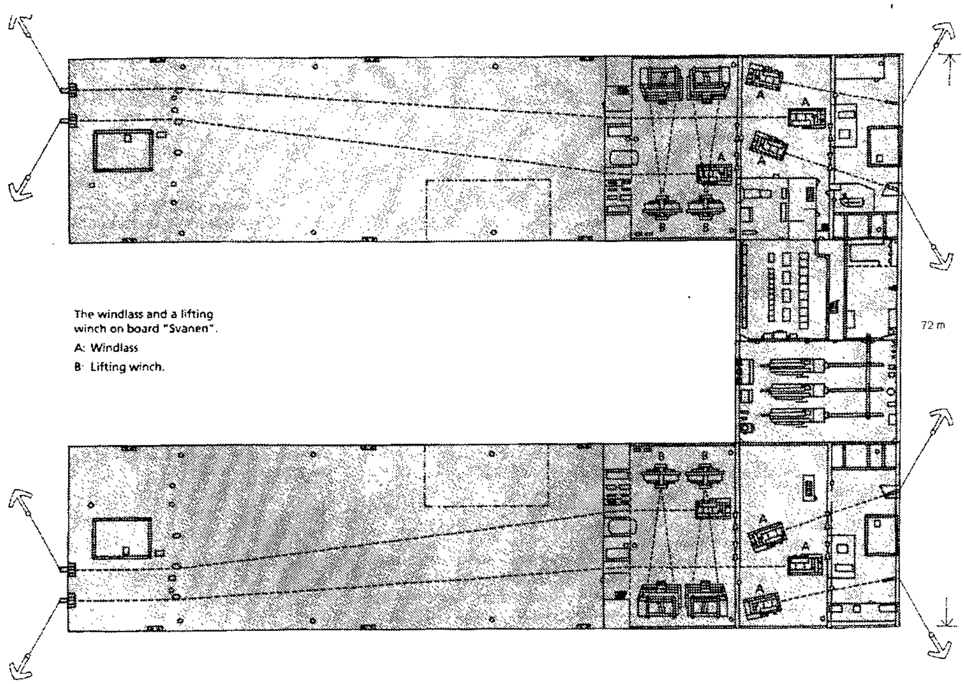


b. Scale model of the catamaran

Figure 40. Typical type of catamaran barge



a. Elevation



b. Plan view

Figure 41. Catamaran with an 8,200-ton lift capacity

Figure 42 shows the *Svanen* placing a main girder of the Prince Edward Island Bridge. The girder measures 192 m in length and weighs 7,500 tons. Lifting and placing such very large and heavy objects requires special care in minimizing impact from the load onto a fixed seating structure. A heavy lift requires multiple parts of hoisting lines, which take time to overhaul as the load is transferred. Even free overhaul is not fast enough to prevent some damaging impact. In this case, hydraulic jacks are installed on top of the bridge pier as energy absorbers.

A catamaran can be fitted with other types of cranes to offer versatility and flexibility. For example, *Rambiz* is a catamaran design fitted with twin shear-leg cranes (see Figure 43). The vessel uses two heavy-lift pontoons for flotation. The twin hulls are linked by a cross beam, which is a seagoing pontoon vessel in its own right. Each crane is rated at 2,000-ton lift capacity and can be equipped with fly-jibs to reach a height of 240 m. The cranes break down into easily transportable sections and can be rapidly re-rigged on heavy pontoon platforms.

Figure 44 shows the layout of a 3,000-ton-capacity catamaran barge proposed for lift-in construction in the inland waterways. Figure 45 shows the proposed catamaran installing precast modules of a tainter gate dam section. The major system components include:

a. Conventional barges 200 by 50 by 15 ft (two, upgraded to handle lift-beam reactions).

b. Steel plate girders designed for the rated lift capacity (two, 210 ft long, 10 ft, 3 in. deep).

c. Hydraulic lifting jacks (eight, rated at 350 tons).

d. Sponsons to provide counterweight during lifting operations (four).

Capacity

Since the catamarans are usually custom designed for lift requirements of a specific project, design loads are determined based on actual component size and handling requirements. Barges, structural members, and hydraulic winches are sized accordingly. For the catamaran shown in Figure 44, plate girders capable of handling 3,000 tons will weight approximatel7y 260 tons each, with an overall length of approximately 210 ft. This design can be adapted to heavier lifts. However, for lifts greater than 3,000 tons, a truss and linear jack arrangement may be more economical.

Availability

Catamaran barges have an inherent advantage over the previously considered lift equipment in terms of availability. All components are "off-the-shelf" and

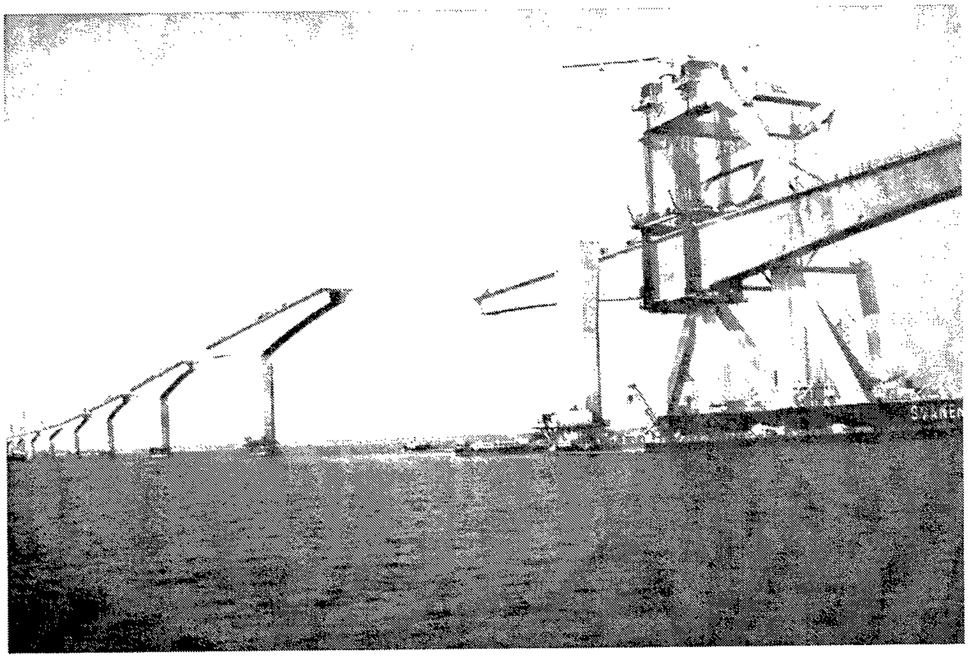


Figure 42. The *Svanen* lifts a 7,000-ton bridge girder segment

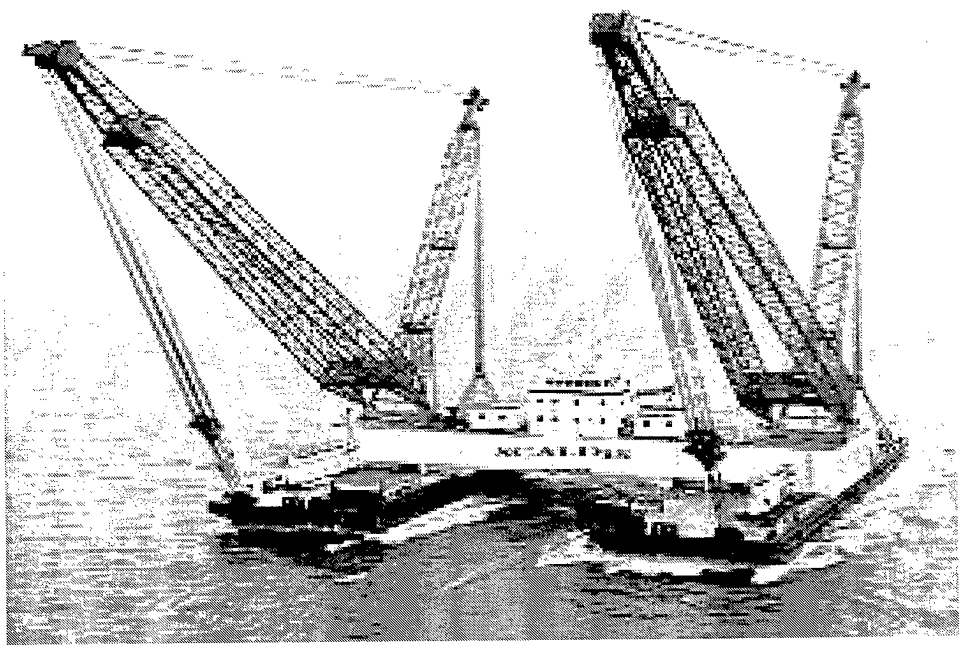
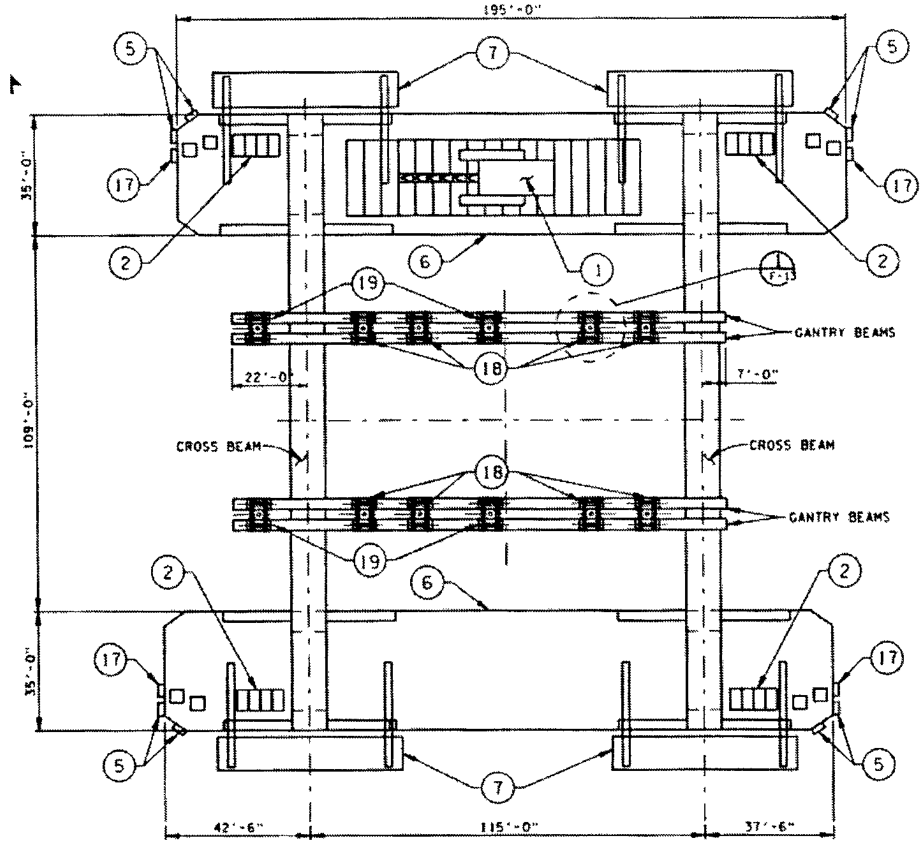


Figure 43. The *Rambiz*, a catamaran with twin shear-leg cranes (barge size: 250 × 230 × 25 ft, lift capacity: 4,000 tons)



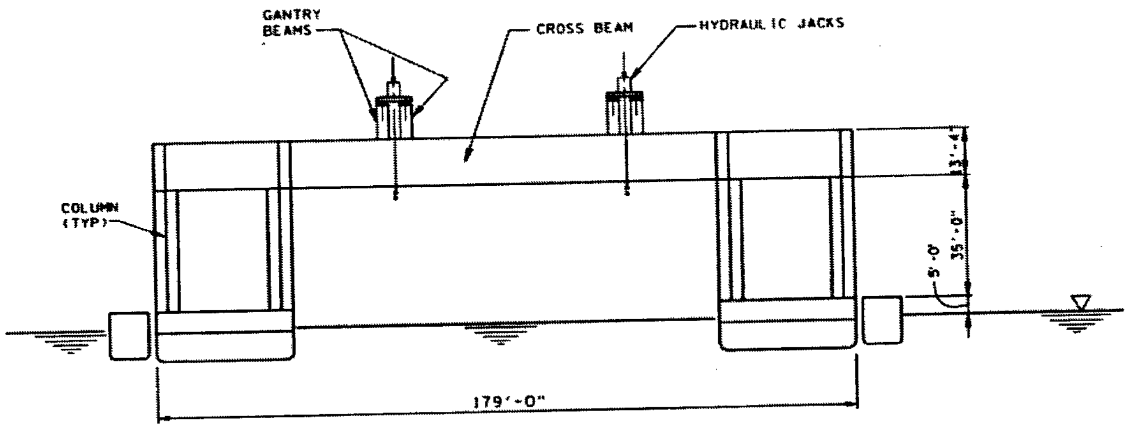
PLAN - CATAMARAN BARGE

SCALE: 1"=20'

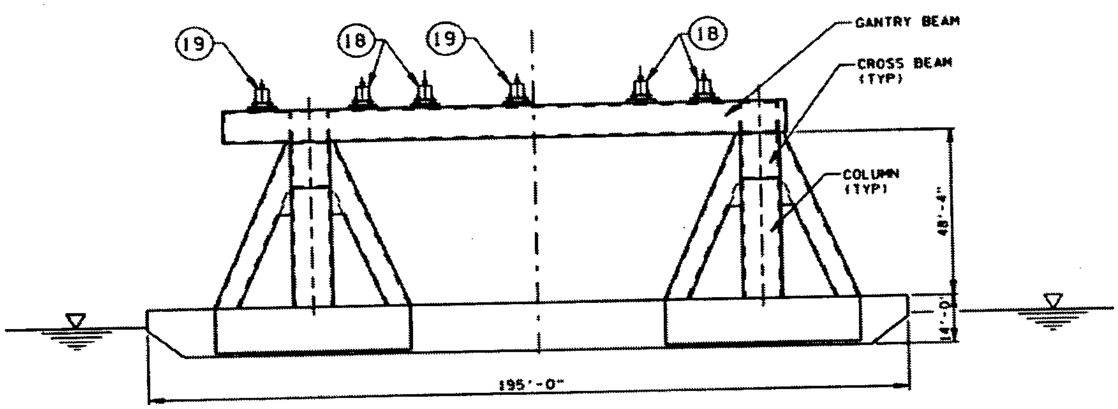
LIST OF BARGE EQUIPMENT

1 (R) MANITOWOC 3900 SERIES 2
2 (R) SKAGIT 3 DRUM WINCH (RB97)
3 (•) HYDRAULIC POWER PACK DSL
4 (•) AIR TUGGER (INGERSOL-RAND V/K4 UL)
5 STEV/FIX ANCHORS 7000 KG
6 BARGE (195' X 35' X 14')
7 SPONSON 10'X50'X13' (OPTIONAL)
8 (•) CAT GENERATOR 150 KW DSL
9 (•) AIR COMPRESSOR - JOY 1300CFM
10 (•) AIR COMPRESSOR DSL (DIVER AIR)
11 (•) DECOMPRESSION CHAMBER (PVHO1)
12 (•) DECOMPRESSION CHAMBER (HP230)
13 (•) PEERLESS JET PUMP (6")
14 (•) POWER PACK FOR HOSE REELS
15 (•) HOSE REELS FOR PIN PULLERS
16 (•) HYDRAULIC POWER PACK AND HOSE REEL FOR COUPLER/WEDGE JACKS
17 LWT/DANFORTH 15T ANCHORS
18 350 TON HYDRAULIC JACK ON SUPPORT FRAME (8 PLACES)
19 200 TON HYDRAULIC JACK ON SUPPORT FRAME (4 PLACES)
20 (•) COUNTERWEIGHT (TO BE USED ON GANTRY BEAM WHEN LIFTING PRECAST PIER WALL)

Figure 44. A proposed catamaran barge for lift-in construction (plan and elevation) (Continued)



FRONT ELEVATION



SIDE ELEVATION

Figure 44. (Concluded)

could be designed, purchased, and assembled in less than 6 to 9 months, depending on the size the complexity of the equipment.

Catamaran barge systems generally do not have any access problems in terms of their width, length, or height, since they are assembled onsite. However, each pontoon must still comply with the physical clearance restrictions imposed by inland waterways. Each of the two pontoons would be towed or pushed to the site in a conventional manner. Structural modifications can be performed at the site, or at a shipyard prior to delivery. Lift beams can also be manufactured at a shipyard, or other steel fabrication facility, and barged to the site for erection. Some care and planning will be required to lift and assemble the beam components, but most structural steel erection companies in the country have the expertise to handle this work.

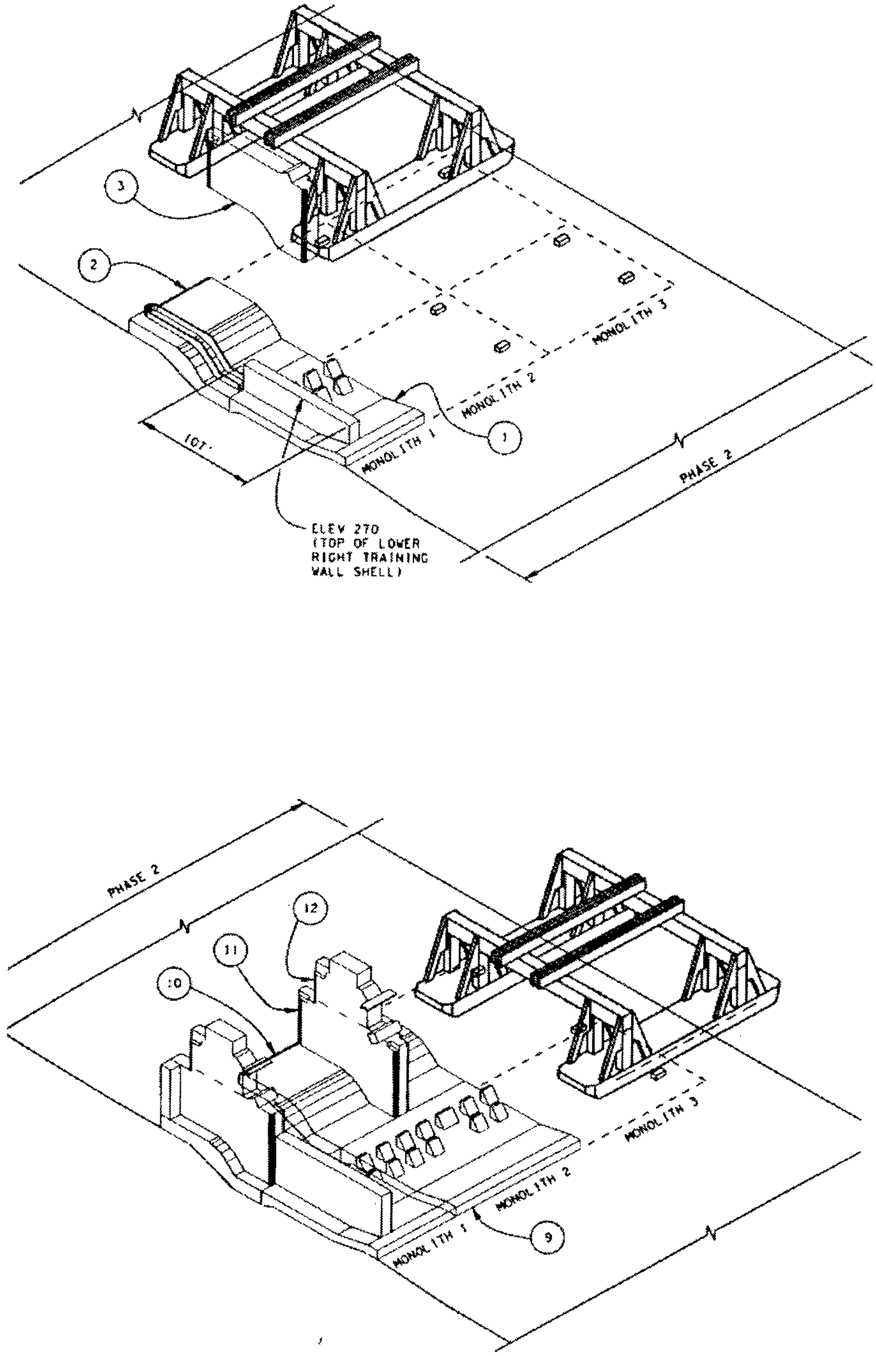


Figure 45. A catamaran installing precast dam segments

Mobility

Catamaran barges are seldom self propelled and require towboats for transport. Because a catamaran must straddle across a load to lift it, precast yards have to be facilitated with a skidway or jetty in order for a catamaran to pick up precast modules from the yard and transport them to the project site.

In general, catamarans often have lower production than derrick barges, and even shear-leg barges. Most catamaran barges do not have movable gantries. The positioning of the modules for final setting must be accomplished by maneuvering the barge itself with deck engines and moorings, tugs, or mounted outboard engine propellers. Some large catamaran barges are equipped with movable gantry beams that are mounted on the cross beams spanning the pontoons (see Figure 44). This arrangement provides adjustable picking points for different sizes of prefabricated modules, and allows positioning of the modules with the movable beams while the barge is moored in one location.

Economics

In general, catamaran barges have relatively low first cost and above-average salvage value. The cost analysis herein is for a typical catamaran barge capable of lifting and transporting 3,000-ton loads. Appendix E presented the detailed cost analysis calculations for the barge. The analysis shows that construction of a 3,000-ton-capacity catamaran barge would cost approximately $8.2 million. This cost includes purchase of barges, structural steel fabrication, barge modifications, hydraulic equipment, lifting frame, and mooring facilities. Salvage on the barges and mooring equipment will probably be on the order of 50 to 75 percent. This type of heavy-lift equipment is generally economical in terms of initial cost and total capital.

The total cost, including mobilization and demobilization, and operating costs, for a 1-year project (with 100 percent equipment utilization) is on the order of $9.1 million. This cost increases to approximately $9.9 million on a 2-year project (working 6 months each year), and to $11.1 million on a 3-year project (again working 6 months each year). Compared with an offshore shear-leg crane barge with similar lift capacities, the catamaran barge generally has significant economic advantages under the same project conditions.

Catamaran Barges with Linear Jacks

This equipment is similar to the catamaran with "lifting beam," except that the hydraulic jacks are mounted directly onto the side of the barge using outboard lifting platforms. This method has the advantage of eliminating plate girders spanning between the barges, and replacing them with steel trusses to carry torsional forces created during the lifting operation. This system can be designed to lift extremely high loads because jack forces are transmitted directly into the barge structure, as opposed to a long-span plate girder in the previous method.

The linear jack system (also referred to as strand jacks) has its origins in the use of high-strength prestressing strand in prestressed concrete. The prestressing technology originally developed for tensioning prestressing cables has become the basis of the strand jacks for heavy lifting. The strand jack system consists mainly of the strands, jacks, power packs, control mechanisms, and support frames.

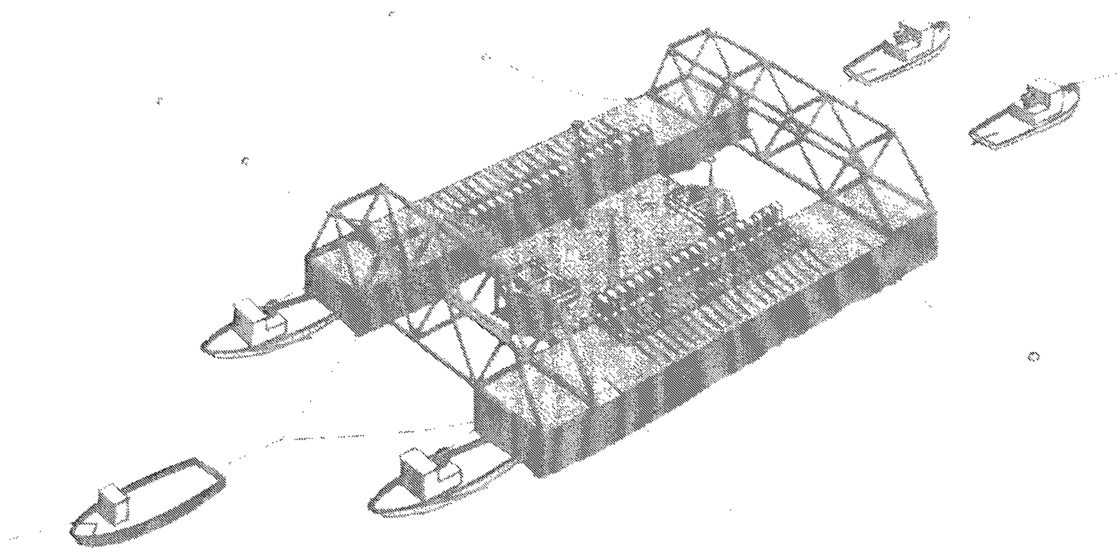
Lifting strands are often made of seven wires in a 6/1 combination. The strands are grouped in a cable, but each strand is anchored individually to ensure the development of the full cable strength and a high degree of redundancy. The strand jacks lift or lower in a series of increments roughly equivalent to the stroke of the hydraulic jacks. During a lift operation, the jack piston is simply extended or retracted in sequence. The wedge grip mechanism automatically locks onto the lifting cable and pulls it through the jack as the piston extends, and then locks it in its new position as the piston retracts to reset. A reverse sequence is used for lowering operations.

The hydraulic jacks range from 15 tons to 600 tons in capacity. Some of the jacks are able to achieve a lift speed of 60 m/hr and positioning accuracy to millimeter tolerance. They can be used in groups to meet high lifting-load requirements. Groups of the jacks may be automatically synchronized in operation speeds by a computerized control system. The control system allows instant access to load and jack stroke data, manual adjustment of all jacks or individual jacks, and real-time plotting of time versus pressure. The actual control and monitoring of the jack systems requires sophisticated arrangement of valves and gauges or transducers or electrical potentiometers. At present, strand jack technology is still considered to be a specialist technical field.

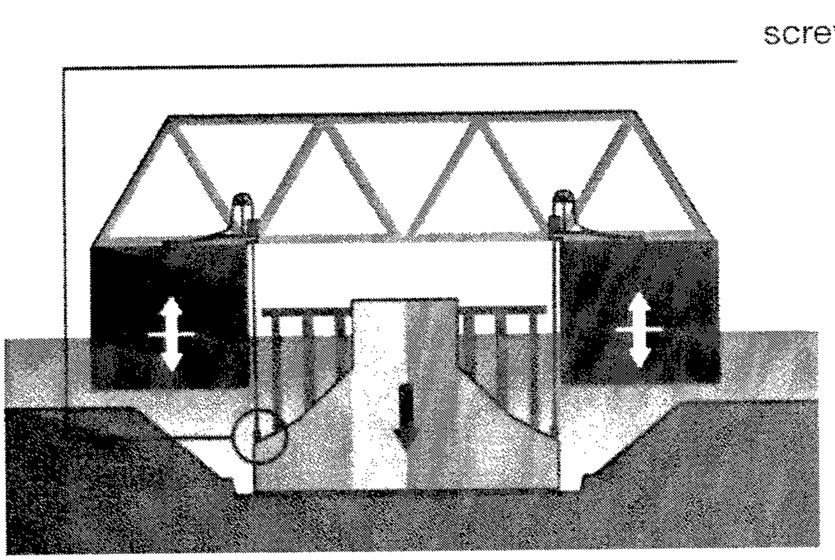
Disadvantages are that the barges must be structurally upgraded to carry eccentric lifting loads from the hydraulic cylinders, through the outboard lifting platforms, and into the barge frame.

Figures 46 and 47 show lifting operations of this catamaran lift system during installation of a caisson foundation of the Oresund Bridge linking Denmark with Sweden. The 1,100-m (3,600-ft)-long bridge has a 490-m (1,600-ft) main span extending between two 204-m (670-ft)-high pylons. Each pylon rests on a huge prefabricated concrete caisson foundation. Each caisson consists of a concrete foundation base (35 by 37 m (115 by 121 ft) in plan) that extends into two pylon towers and measures 22.5 m (74 ft) in height. The dry weight of a caisson was 20,000 tons.

A custom-designed catamaran was used to lift the caissons off the graving dock and move them to the bridge site. The catamaran consisted of two barges tied together with two large steel trusses. Each barge was equipped with twenty VSL SMU-330 hydraulic strand lifting/lowering units, each with a lift capacity of 330 tons. Figure 47b shows the VSL hydraulic lifting units hanging from the inner edges of the barge through steel trusses. All 40 units (with 13,200-ton lift capacity) were remotely controlled from a single control center.

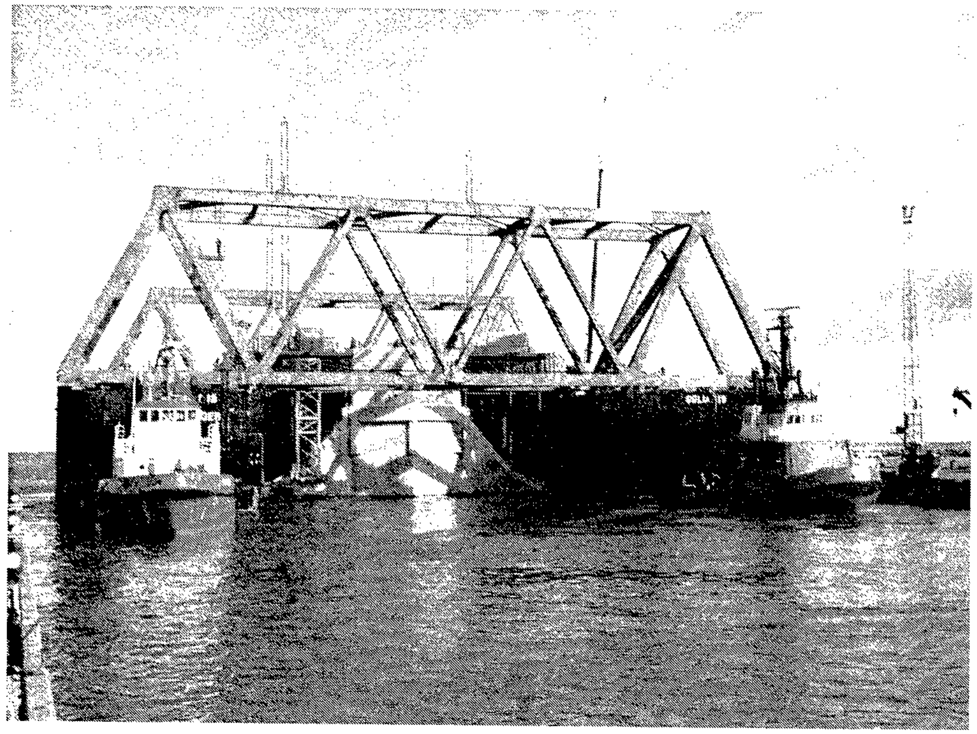


a. Catamaran carrying a caisson of the Oresund Crossing Bridge

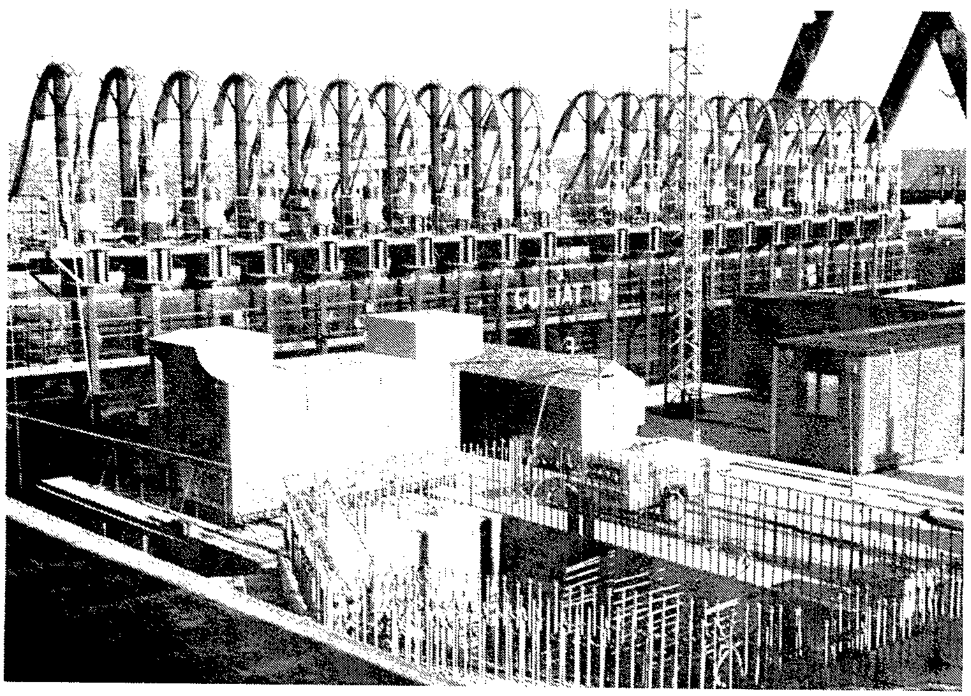


b. Catamaran lowering a caisson onto prepared foundation

Figure 46. Lifting operations of a catamaran during installation of a caisson foundation of the Oresund Bridge, Denmark-Sweden



a. The 20,000-ton bridge caisson hanging on the barges by 40 linear jacks (two pontoons are connected with steel trusses)



b. Forty VSL SMU-330 linear jacks lifting the bridge caisson

Figure 47. Bridge caisson and VSL hydraulic lifting units

The entire lift-in operation followed a carefully thought-out sequence: the graving dock was flooded after completion of the caissons. The catamaran was positioned above the caisson, and 40 lifting tendons were coupled with the load. The caisson was then lifted until the draft of the catamaran and caisson became equal. At this point, the catamaran needed to carry only a 12,000-ton vertical load due to buoyancy of the partially submerged caisson. A 110-percent load test had to be carried out prior to the actual towing. This test was done by lifting the caisson 1 m farther out of water. Five towing tugs were used to navigate this caisson-catamaran system through a 12-km route to the bridge pylon site. During the tow-out, the caisson was hanging free on lifting cables, and fenders were used to prevent the caissons from freely swinging.

Positioning of the caisson at the pylon site had to achieve an accuracy of 75 mm (3 in.) in plan and within 2-deg rotation angle. Because the site was too far away from the shore for land-based surveying, DGPS was used to allow continuous comparison between the actual and required positions. Positioning was controlled by a system of winches and mooring cables leading to eight anchors. Once the caisson was positioned within acceptable tolerances, it was lowered with a three-point suspension system coordinated from the control center. As the buoyant weight of the caisson decreased during lowering, the barges had to be ballasted in order to keep the catamaran draft constant. At touchdown, the suspension weight of the caisson was still 3,000 tons. The load transfer was critical because the caisson needed to quickly establish stability. This was accomplished by a combination of hydraulic lowering and ballasting of the barges.

The main advantages of this type of catamaran are listed below.

a. With use of linear jacks from one side of the barges, lift capacities of this type of catamarans are practically unlimited.

b. Since the lifting jacks are supported by the frames of the barges, lift beams are eliminated, resulting in substantial cost saving.

c. Catamaran barges are usually custom designed for specific projects. This offers unique advantages in load-handling, positioning, stability, and economy.

d. There is no system eccentricity, since the hydraulic cylinders are mounted symmetrically about the load. Catamarans therefore do not tend to pitch or roll during lifting and setting loads. Among all the floating cranes, catamarans offer the greatest floating stability during installation of prefabricated modules. For the same reason, catamarans have much higher lift capacity than other types of cranes for a given winch power.

e. Heavy lifts are possible from relatively inexpensive hydraulic equipment.

f. By locating the trusses at the ends of the barges and clear of the segment being lifted, the segment can extend above the stabilizing trusses.

g. Equipment components are custom designed and assembled at the site, eliminating physical clearance conflicts during transport.

h. Hydraulic equipment provides smooth operation and control.

i. River contractors are more familiar with catamarans than any other crane barges.

Capacity

Catamaran barges are custom designed and constructed for a specific project. Lifting capacities are determined on the basis of prefabricated component size and handling requirements, and structural members and hydraulic equipment are sized accordingly. By hanging lifting jacks from one side of the catamaran barges, the lift capacities of this type of catamarans are practically unlimited.

Availability

Catamaran barges equipped with lifting jacks are constructed from off-the-shelf components that are readily available. All components can be designed, purchased, and assembled in 6 to 9 months.

Catamaran barge systems do not have any limitations in terms of width or height since they are assembled onsite. Each of the two individual barges would be towed or pushed to the site in a conventional manner. Structural modifications could be performed at the site, or at a shipyard prior to delivery. Structural trusses can be manufactured at a shipyard or other steel fabrication facility and barged to the site for erection. Some care and planning are required to assemble the stabilizing trusses onto the barges. However, most structural steel erection companies in the country have the expertise to handle this type of work.

Mobility

Catamaran barges are seldom self propelled and require towboats for transport. Because a catamaran must straddle across a load to lift it, precast yards have to build a skidway or jetty in order for a catamaran to pick up precast modules from the yard and transport them to the project site. During positioning of the modules for final setting, the catamaran must move close to the final setting position (within a few inches), because there is little room for the lift beams or gantries to maneuver. Thus, catamarans often achieve less production than derrick barges, and even shear-leg barges.

Economics

In general, catamaran barges have relatively low first cost and above-average salvage value. Appendix F includes cost analyses of a catamaran barge with linear jacks capable of lifting 3,000-ton loads. The analyses show that the initial cost of such a catamaran would be approximately $8.8 million. This cost includes barges, structural steel fabrication, barge modifications, hydraulic equipment, and

mooring facilities. It does not include related launching facilities at the precast yard. The salvage value for barges and mooring equipment is on the order of 50 to 75 percent. The total equipment cost, including capital, mobilization and demobilization, and operating costs, for a 1-year project (working 12 months each year) is on the order of $9.7 million. This cost increases to approximately $10.5 million on a 2-year (working 6 months each year) project, and $11.7 million for a 3-year project (working 6 months each year).

Float-over Method and Equipment

The float-over method is a recently developed installation technique in the offshore industry for mating topside decks with jackets. It is intended to be a low-cost system for installing very heavy platform decks (including the major equipment on the deck) onto substructures in a single lift-in operation.

The float-over operations for installation of a platform topside are as follows. A fully integrated deck module (usually weighing more than 10,000 tons) is loaded out onto a flat-top cargo barge and properly fastened on support assemblies with bearing plates and jacks. The barge is towed to the project site and maneuvered inside the slot between the supports of the preinstalled jacket (see Figures 48 and 49). The barge is moored to the jacket with stiff hawsers and contacts between the barge, and the jacket legs are damped with fenders.

Once properly positioned, the deck is installed through several jacking/ballasting stages:

a. A slow ballasting to increase the barge draft by a few feet.

b. Once the jacket conical receptacles are already within the deck-docking piles and there is no risk of them getting out, a fast jacking-down is performed to transfer 70 to 80 percent of the deck weight to the jack.

c. A slow ballasting/jacking is performed with no load transfer. Jacks are extended simultaneously with ballasting of the barge.

d. A fast jacking-down is performed to quickly transfer the entire deck weight on the jacket, and jacks are rapidly retrieved to avoid repeated impacts on the jacket due to wave motions.

e. The barge is ballasted down, free of the deck, and towed away.

Major equipment components for float-over operations include the following items:

a. *Jacking system.* The hydraulic jacking system is the key component of the installation. The system must allow a fully reversible operation by remote control. It is specifically designed for an even load distribution to all the

supports. The jacking system must have speedy travel capacity to quickly transfer the load, to avoid overloads caused by wave motions.

b. *Ballasting system.* The ballasting system is designed to ballast or deballast the barge to facilitate the load transfer from the barge to the supports, and then towing out the barge.

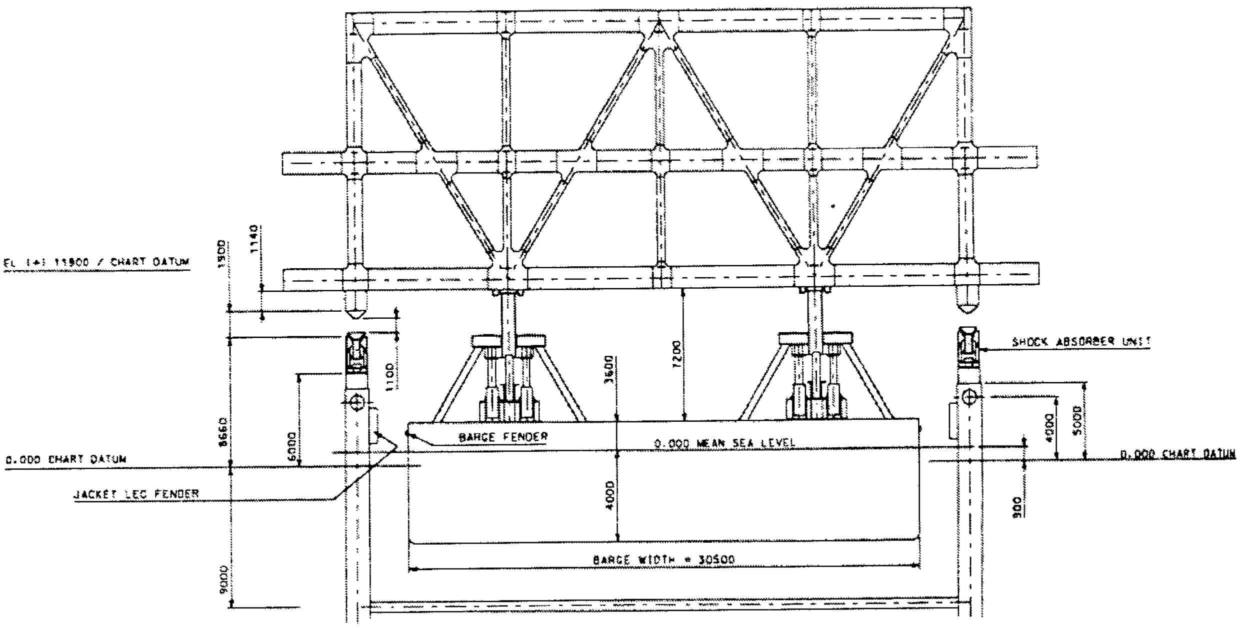
c. *Mooring system.* The mooring system is sized to comply with the barge motion characteristics and the environmental condition. It consists of mooring lines, winches, fair-leads, and bollards. The arrangement of the lines and their pretension load provide precise positioning of the barge.

d. *Shock absorbers.* The shock absorbers are designed for several purposes. First, the absorbers provide a smooth positive guide of the lift-in module into the supports during the ballasting phase. At the end of the ballasting, the module will be safely engaged onto the supports without generating excessively hard impact. This requires that the absorbers provide appropriate axial and lateral rigidity to transfer the weight of the module and to accommodate the motion of the barge. Second, the absorbers must progressively control the relative motion of the module with respect to the supports during the jacking-down operation. The third purpose of the absorbers is to provide a precise guide for mating of the module with the supports.

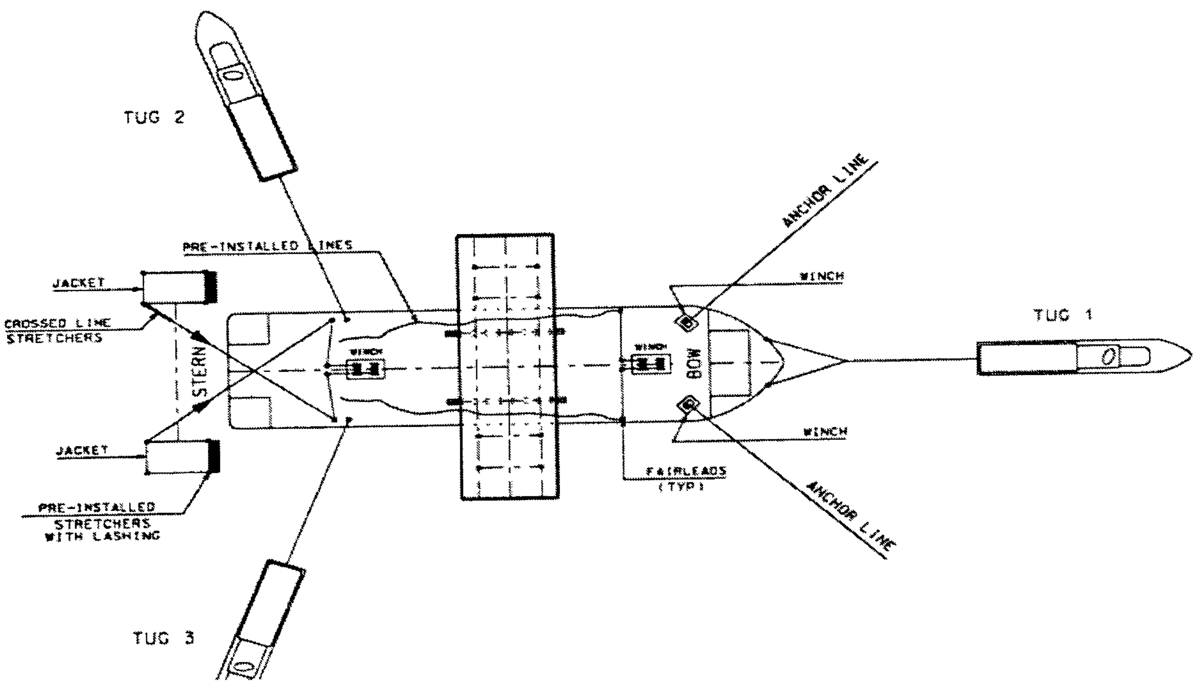
e. *Control system.* The control system must be able to monitor a number of operations: the hydraulic jack system (pressure, flow rates); jack extension and load at each support; barge configuration (such as draft, heel angle, and center of gravity); barge position with respect to the support using DGPS; and tension in mooring lines.

Although the float-over system is simple to rig up, test, and operate over water, the design is sophisticated. The float-out system is designed to avoid the development of large reactions resulting from wave-induced motions during the float-over, rather than to resist large reactions once developed. Large reactions in the horizontal plane are avoided by partially restraining the relative motion between the barge and the jacket. The vertical impact loading is substantially reduced by a "motion-based" system, as shown in Figure 50.

The impact-absorbing system consists of sand valves and shock absorbers. The shock absorbers are cylindrical telescoping rams projecting below each deck leg. As the barge is ballasted down to mate the deck with the jacket, shock absorbers land on "flat tops" and react against a stack of rubber disks inside each deck leg. Thus, the axial load in the rams is limited by the rubber disks, as determined by its load versus distortion relation. This eliminates any vertical impact loading as the deck lands on the jacket. The flat top is at the top of a piston inside a "sand can" (see Figure 50). Once the float-over is completed, the sand is drained through the valves causing the piston to travel downward, stabbing the deck legs into the sand cans. The deck legs are girth-welded onto sand cans to complete the installation.



a. Mating a topside module with jacket supports (the float-over method)



b. Positioning the prefabricated module between jacket supports

Figure 48. Illustration of the float-over method

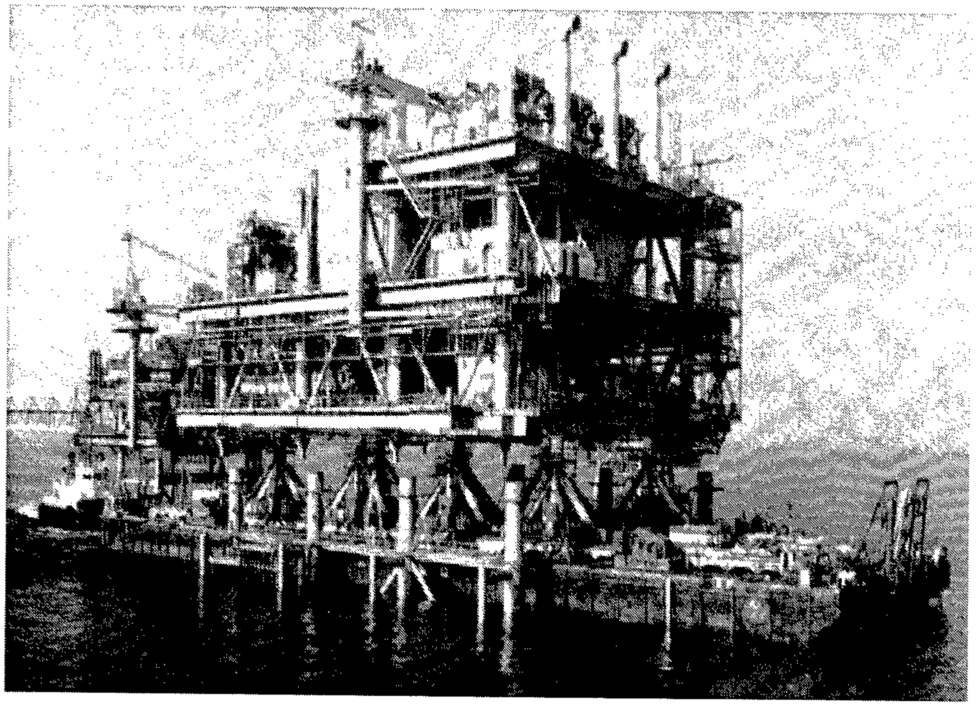


Figure 49. Alignment of a 5,000-ton integrated deck module with the jacket before lowering (the float-over method)

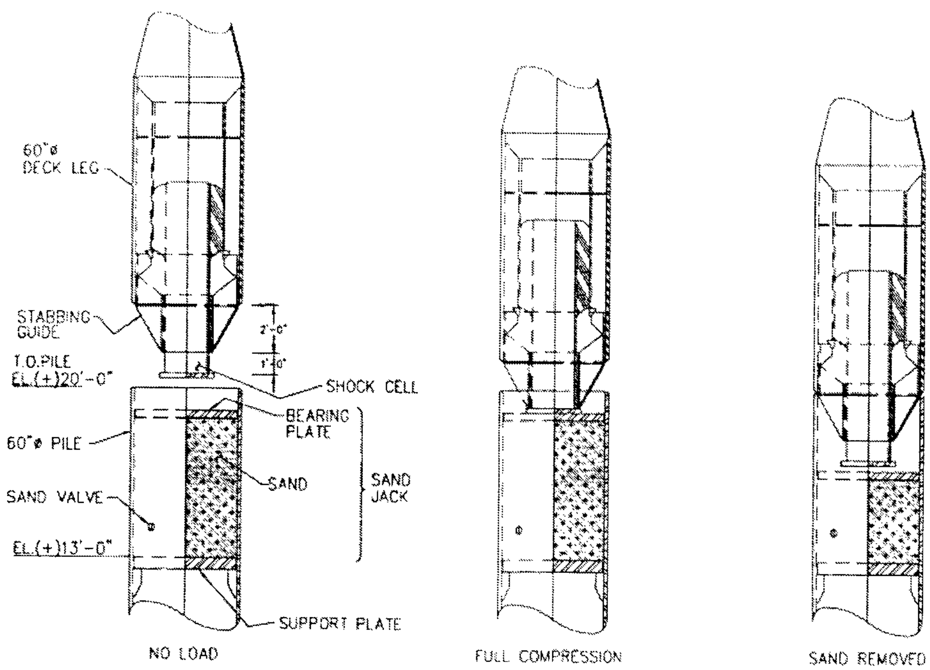


Figure 50. Mating assembly details

The main advantage of the float-over method is that a very heavy fully integrated deck can be installed in a single lift with relatively simple equipment and operations. It can be easily maintained and tested in a marine environment and is simple to operate over water. Its simplicity leads to system reliability and construction quality. The method is especially valuable when the weight of a prefabricated module exceeds the capacities of heavy-lift vessels or if suitable lift vessels are not readily available. Platform decks up to 20,000 tons have been installed with the float-over method in a 6-in. wave environment.

In principle, the float-over concept is equally applicable for installing prefabricated modules to construct navigation structures. It is perceived that the float-over method may potentially provide substantial savings for lift-in construction. Several float-over systems are currently available, such as the Brown & Root high-deck system and the ETPM smart-leg system, although these systems are designed for offshore operations.

The float-over lift method is primarily for placing prefabricated modules above water. Therefore, to place precast modules underwater with the float-over method, the configuration of the transport barges and arrangement of hydraulic jacks would have to be re-engineered to meet special requirements.

Versatruss Lift System

A Versatruss lift system uses two barges and an array of booms, rigging, and winches assembled into a single lifting unit that essentially acts as a scissors jack (Figure 51) to lift an object located between the barges. This system has been successfully used to salvage offshore oil platform decks up to 6,000 tons. Lifts up to 20,000 tons are currently under planning and design. There are several unique features to this method that provide substantial advantages for heavy lifts, but also lead to inherent limitations.

The lift process begins by locating a barge equipped with a suitable number of A-frame booms (typically four frames per barge) on either side of the deck to be lifted. The A-frame booms are manufactured from structural pipe and are mounted on frames attached to the center line of the barge. The rigid A-frame boom tips engage rigid receptors attached to the deck. Multiple deck winches, with suitable rigging and load blocks, are attached to the opposite barge or the deck's lower level beams.

When the winch pulls the barges closer to each other, the booms continue rotating upwards, imparting a vertical force component to the deck and raising the deck. Boom angles are generally greater than 25 deg at the start of the lift and not more than 75 deg at the end of the lift.

The primary advantage of the Versatruss lift system is the ability to install a very heavy module in a single lift. Other advantages include the following:

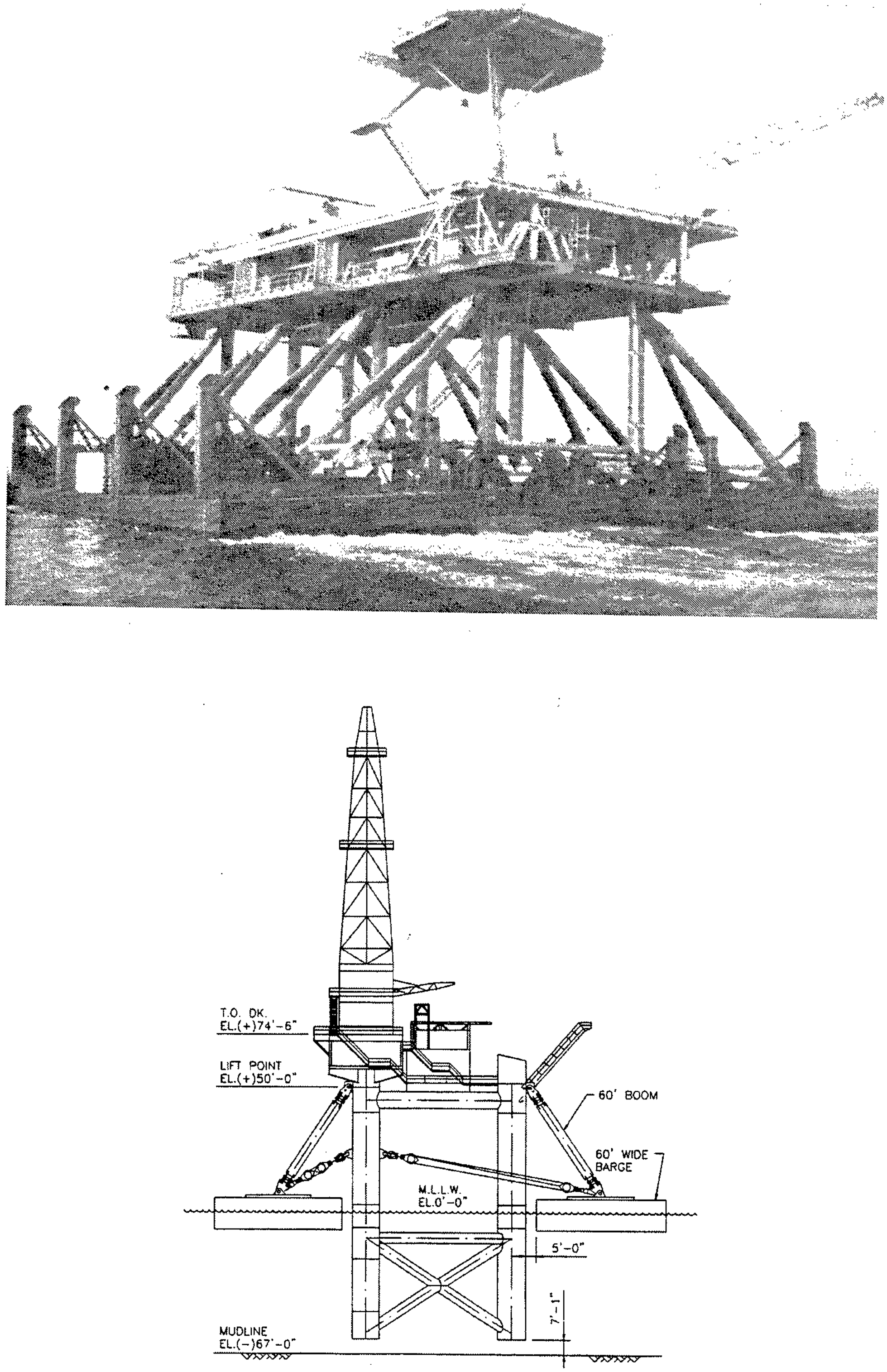


Figure 51. A 1,500-ton Versatruss lift system carrying an offshore platform topside

a. The system is ideal in very shallow water where access for a large crane barge is not feasible.

b. It does not require a sophisticated mooring system.

c. It is not limited by height restrictions in its access route.

d. There is practically no limitation on its lift capacity.

Lift-in construction of navigation structures will typically require lowering heavy loads onto the riverbed and will involve hoisting and placing concrete elements that are relatively limber. To maintain handling stresses and deflection within acceptable limits, a stiffening frame must be attached to the element. This frame will be roughly the same plan dimensions as the element, and will have a minimum height roughly equal to the distance from the river surface down to construction subgrade, plus a small additional amount to project the frame above the water surface (to aids in the erection process). Figure 52 shows a scheme to lower a large flat precast module onto a riverbed by using a Versatruss and a lift frame.

While the lifting forces are limited only by the structural capacity of the components in the system, there are some physical limitations in terms of using the Versatruss system for in-the-wet construction:

a. *Boom geometry limitations.* For a given boom length, initial boom angle, and final boom angle, one can determine the maximum distances of vertical lift and horizontal barge travel during the lifting process. If the boom angle ranges from 25 to 75 deg, the Versatruss would require a boom length approximately 85 percent greater than the required vertical travel distance, resulting in handling difficulties.

b. *Structural limitations.* As discussed earlier, the Versatruss system works by applying tension to deck winches, and thereby forcing the boom tips to move upward. This action creates significant compressive forces between the connecting members of the lifted module. The connecting members have to be specially designed to carry the significant compression force.

c. *Installation limitations.* Inherent to the Versatruss system is an assumption that the barges are free to move relative to each other during the raising or lowering process. In other words, the Versatruss barges, lifting gear, and the load are free-floating as one unit, or at the most, only one of the barges is moored in a fixed location. This arrangement ensures that the load will translate horizontally during lifting or lowering operations. If the assembly is free to float during hoisting operations, push boats will be required to provide positioning control. River currents acting on a free-floating assembly will add significant problems to maintaining position. In all likelihood, controlling and positioning the floating assembly with push boats will not meet installation tolerances required for in-the-wet construction.

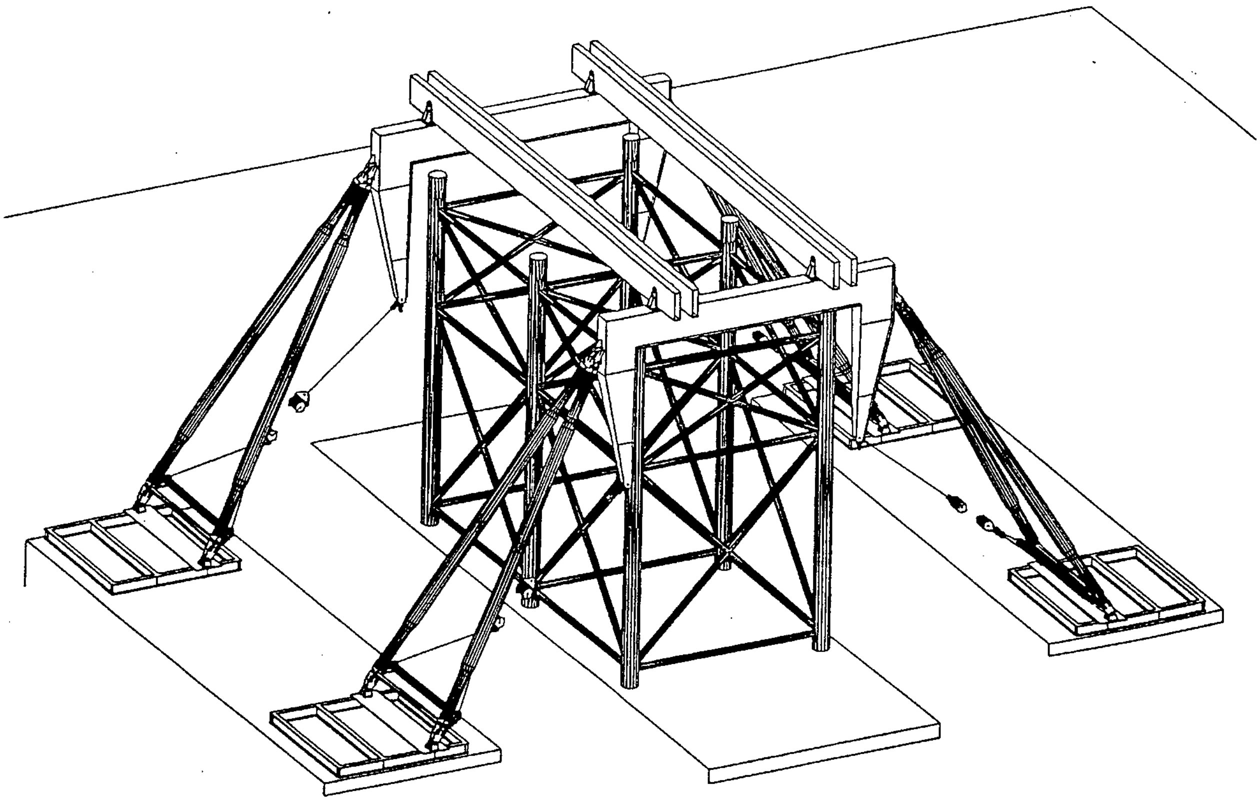


Figure 52. A proposed scheme to lower a large, flat, prefabricated module onto seafloor or riverbed using a Versatruss and a lift frame

In summary, the Versatruss lift system is very effective in lifting and setting very heavy loads over relatively short vertical distances. The prefabricated module must be designed to carry the compression forces from the boom thrust without buckling. Evaluation of the Versatruss system with respect to inland waterways lift-in construction indicates that this system may offer some advantages under some special circumstances. However, it has some structural and installation limitations for universal applications.

4 Summary and Conclusions

Lift-in construction entails transportation and installation of prefabricated elements by heavy-lift equipment. The lift-in method for lock and dam construction is basically an extension of the existing marine construction methods used to construct offshore structures and bridges. In the past, many major marine construction projects have fully demonstrated the feasibility and economy of lifting and setting very large prefabricated modules underwater or over water. However, the construction methods and lift equipment used in offshore applications would be subject to the various constraints of inland waterways, such as bridge headroom clearance and draft requirement.

A variety of lift equipment is applicable for lift-in construction. Selection of suitable lift equipment is an important design decision. Each type of lift equipment has associated implications with regard to project cost and schedules, positioning accuracy, tow and mooring systems, and level of risks during construction. In many ways the lift equipment will, at least in part, determine the size and configuration of precast concrete modules, the foundation tie-in, and construction logistics.

In general, a thorough evaluation should be made in the early stage of design to determine the effects of the lift equipment on construction cost and logistics. Selection of lift equipment should be based upon project-specific requirements and availability of lift equipment. Important factors to be considered in the selection include the following:

a. Weight and size of the precast components.

b. Availability of the lift equipment in the commercial market.

c. Cost of the equipment (initial cost and salvage value).

d. Lift equipment utilization rate.

e. Logistics of installing precast segments at the site.

f. River condition at the time of construction.

g. Navigation restrictions along the access route for the crane barge.

h. Maneuverability of the crane barge and its productivity for intended operations.

i. Floating stability and ability of the equipment to position prefabricated modules within the prescribed tolerance.

j. Meteorological and hydrological conditions onsite for the anticipated lift work window.

k. Method of transporting precast components from the prefabrication yard to the project site.

l. Navigation traffic through the site during lift-in construction.

This study evaluated the most common lift equipment and some recently developed lift systems with respect to their cost and suitability for inland waterway construction. The following lift systems were discussed in the report:

a. Lattice-boom heavy-lift crane, ringer-mounted or pedestal-mounted on floating barge.

b. A-frame type (shear-leg) crane barge.

c. Offshore crane barge.

d. Jack-up crane barge.

e. Catamaran barge with lifting beams or gantries.

f. Catamaran barge with linear jacks/rods.

g. Float-over system.

h. Versatruss lift system.

Cost analyses of the lift systems were performed for different project durations and utilization rates. In general, the cost of utilizing heavy-lift equipment for a project is primarily a function of the equipment size and type, utilization rate, project duration, ownership (purchase versus lease), and equipment salvage value. The analyses indicate that if heavy-lift operations must be performed intermittently over an extended period, it is usually economical to purchase or assemble a custom-built crane barge and salvage it after the completion of the project. On the other hand, if a project requires only a few heavy lifts within a short period of time, it may be more practical and economical to lease suitable lift equipment.

Each of the lift systems has its own distinct characteristics with regard to lift capacity, availability, mobility and productivity, and economics. Table 5 outlines the general characteristics of the lift systems evaluated, as summarized below.

- The ***revolving derrick barge*** is the most versatile equipment for lifting and installing prefabricated modules. It can pick loads on the side or on deck of the crane barge itself, and can quickly reach any point in three-dimensional space with one set of controls. The mobility and versatility of the derrick barge can significantly increase productivity of lift-in construction. The revolving derrick

Table 5
Summary of Basic Features of Crane Barges for River Construction

Equipment Type	Lift Capacity	Availability	Mobility and Productivity	Economics
Revolving derrick barges	Lift capacity is usually limited to 500 tons for river works.	Purchase and assembly of a derrick barge requires 3 to 6 months.	The most versatile and productive lift equipment for lift-in operations.	High purchase cost and high salvage value. Its overall cost can be competitive.
Shear-leg crane barges	Crane barges with up to 800-ton lift capacities are available. Assembly of 3,000-ton capacity crane barges is feasible.	To purchase and assemble a derrick barge usually takes 6 to 12 months.	Less versatile and productive than derrick cranes, but more productive than catamarans. Offer better floating stability than derrick cranes.	The least expensive in terms of first cost and maintenance. The salvage value of shear-leg cranes is low, but overall cost is still competitive for large-capacity crane barges.
Offshore crane barges	Offshore cranes up to 800-ton lift capacities are available for inland waterway construction.	Availability depends on offshore construction seasonality. Clearance restrictions can be a problem for large offshore crane barges.	Depends on the type and size of the lift vessels.	Rental rates can vary considerably, depending on the required work window, the offshore construction market, and seasonality.
Jack-up crane barges	Up to 2,500-ton capacities are available. Lift capacity is often determined by bearing capacity of the spud piles and strength of barge platforms.	Usually do not have access limitations to project sites. They can be purchased or leased with approximately 6-month lead-time.	Very effective in turbulent water or swift current, and can place objects below or above water to tighter tolerances than other types of floating cranes.	Cost is not the lowest. They are normally used to meet special project requirements (e.g., positioning accuracy).
Catamaran barges	Over 10,000-ton lift capacities can be achieved.	Purchase and assembly of a catamaran usually requires 6 to 9 months.	Offer the best floating stability, but less productive.	First cost is low, and salvage value is above average. Cost effective under most circumstances.
Float-over lift system	Over 25,000-ton lift capacities can currently be achieved.	Several float-over systems are available from the offshore industry.	Most suitable for making only a few heavy lifts above water.	Simple equipment and cost effective under special circumstances.
Versatruss lift system	Up to 20,000-ton lift capacities can currently be achieved.	Versatrusses are available in the United States. Custom-built systems can be ordered.	Most suitable for making only a few lifts.	Simple equipment and cost effective under special circumstances.

barge has lifting capacities ranging from 457 tons at a 55-ft radius directly over the stern down to 229 tons at a 110-ft radius with 360-deg rotation. These capacities appear sufficient to handle a significant proportion of heavy-lifting operations in inland waterways. The cranes are readily available from several manufacturers in the United States. All of the equipment components can be delivered to the job site, and assembly can be completed within 3 to 6 months.

Although the revolving crane barge generally costs more than many other types of lift equipment, it has high salvage value. For a 1-year project, possibly the full purchase price of a revolving crane can be obtained at the end of construction. Salvage on the floating barge may be on the order of 50 to 75 percent of purchase.

Typical revolving derrick barges in inland waterways have lift capacities from 20 to 500 tons. This upper limit of the lift capacity is imposed in order to avoid excessive list with the revolving boom. When loads exceed 500 tons, the shear-leg crane barge or the catamaran is usually more viable for inland waterways construction.

- The ***shear-leg crane barge*** is the simplest and least expensive lift system for heavy lifts in rivers, both in first cost and in maintenance. The shear-leg barge offers the advantage of inherent stability in lift-in operation, resulting in higher lift capacity. On the other hand, shear-leg cranes are less versatile and productive in handling loads than the revolving derrick cranes. Shear-leg cranes currently have much lower salvage values than revolving derrick cranes. If such a crane barge has to be purchased and assembled specifically for a project, the contract usually charges 30 to 50 percent depreciation cost to the project.

Some shear-leg crane barges currently operating on inland waterways have lift capacities in excess of 700 tons. Shear-leg crane barges with up to 3,000-ton lift capacity are feasible for inland waterway construction. A shear-leg crane barge can be purchased in components and assembled onsite within 6 to 12 months. Testing and obtaining operation certifications may require an additional 2 to 3 months.

- ***Offshore crane barges*** are available in a wide range of types, sizes, and capacities. Physical clearance restrictions will significantly limit the usefulness of the largest offshore cranes for inland waterway construction. These limitations include overall beam width, transport height, and draft requirements of the vessels. Nevertheless, a large number of moderate-size offshore crane barges (rated up to 800-ton lift capacity) are able to access to most inland waterway sites.

The market for these offshore lift vessels is very fluid, and the equipment availability for any specific period of time usually cannot be guaranteed in advance without a contract. Rental rates for these crane barges can vary considerably, depending on the required work window, the offshore construction market, and seasonality. If heavy lifts will be performed in a short period (e.g., several weeks or 1 to 2 months), using a suitable offshore lift vessel is practical and can be cost effective. In these short-term leases, mobilization and demobilization could become a significant portion of the rental cost. Therefore, the projects have to be a certain scale and value for an offshore crane barge to be competitive for inland waterway works. If heavy lifts must be performed intermittently over an extended period, it is economical and practical to assemble or purchase a custom-built crane barge and salvage it after completion of the project.

- ***Jack-up crane barges*** have proven to be very effective heavy-lift equipment in turbulent water or swift current. Due to its inherent stability, the jack-up barge can place objects below or above water within much tighter positioning tolerances than other types of floating cranes. Furthermore, lift capacities of cranes mounted on jack-up barges are rated about 50 percent higher than those of floating cranes. Large jack-up cranes rated up to 3,000 tons are generally available in the commercial market, but will require approximately 6 months lead-time to acquire

(either purchase or lease). Total cost to purchase/assemble a 2,500-ton-capacity jack-up crane barge is currently in the range of $22 to $25 million. Contractors usually have to take a 30- to 50-percent write-off cost for the barge. The depreciation of the cranes is about 5 percent per year.

The suitability of the jack-up barge for heavy lifts in inland waterways depends greatly on the project site condition. Soil conditions at the site are critical for supporting the crane barge. It is essential that soil bearing capacity be verified to ensure acceptable levels of spud pile settlements. Under many circumstances, the lift capacity of a jack-up crane barge is determined by the bearing capacity of the spud piles and strength of the barge platform. Jack-up barges normally require 5 to 7 ft of river draft and work in water depths up to 200 ft. Thus, the barge can travel to and work in almost all the inland waterway construction sites.

A jack-up crane barge performs very effectively when many lifts have to be carried out at one location, because barge relocation is one of the most difficult operations. Statistical studies of past construction accidents show that jack-up barges are approximately six times more likely to incur serious damage during relocation and transit than they are in jack-up position during lift operations, primarily due to the high center of gravity and, correspondingly, decreased stability with spud piles up.

- ***Catamaran barges*** equipped with two lifting beams and hydraulic jacks are one of the most common and versatile crane vessels for heavy lifts in inland waterways. The main advantages of catamaran barges are these: the vessel is custom-designed to lift and position loads for specific projects; heavy lifts do not cause significant list of the barges; heavy loads can be carried by less expensive hydraulic winches or jacks; heavy-lift equipment can be easily assembled at the site from conventional components; hydraulic winches or a jack system can provide smooth operations and reliable control; and river contractors are more familiar with the catamaran than other types of crane barges.

In general, catamarans are less productive than derrick barges, and even shear-leg barges. However, catamarans offer the greatest floating stability among all the floating cranes and have much higher lift capacity for a given winch power. They also have relatively low first cost and above-average salvage value. Since all the components of a catamaran can be easily delivered to and assembled at the site, there is no limitation on the size of a catamaran barge except that each individual pontoon should comply with the common restriction imposed by the inland waterway in terms of width, length, and height.

Various types of catamaran crane barges have been built. A common type of catamaran is simply two pontoons connected by two lifting beams or gantries. An alternative is to replace the lift beams with lighter trusses and hang lift jacks directly over the side of the pontoons with outboard lifting platforms. This type of catamaran has all the advantages of the catamaran fitted with lifting beams or gantries. In addition, its lift capacity is unlimited, because the lift loads are supported directly by the barge frames rather than the lift beams or gantries. By

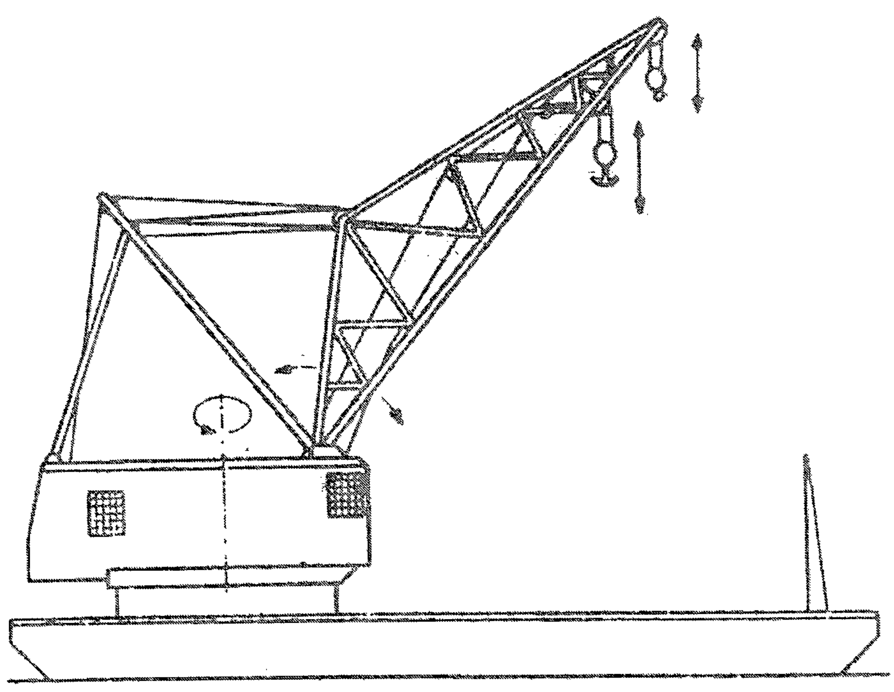
locating the trusses at the ends of the barges and clear of the segment being lifted, the segment can extend above the stabilizing trusses.

- The ***float-over and Versatruss systems*** are recently developed lift techniques in the offshore industry. With these methods, very heavy prefabricated modules can be installed by relatively simple equipment in one single lift. These new technologies may not be universally applied to inland waterway construction, but they can be applicable under certain special conditions with substantial savings.

- The ***float-over method*** is developed for mating integrated topside decks with preinstalled jackets. The main advantage of the float-over method is that a very heavy deck module can be installed in a single lift with relatively simple and low-cost installation equipment and operations. The equipment is simple to operate over water and can be easily maintained and tested in a marine environment. The method is especially valuable when the weight of a prefabricated module exceeds the capacities of heavy-lift vessels or if suitable lift vessels are not readily available. To placing precast modules underwater, however, the float-over system has to be re-engineered to meet special requirements.

- The ***Versatruss lift system*** is very effective in lifting and setting heavy loads over relatively short vertical distances. The primary advantage of the lift system is its ability to install a very heavy module in a single lift. It is not subjected to the draft and height clearance restrictions of inland waterways and does not require a sophisticated mooring system. There is practically no limitation on its lift capacities; however, it has some structural and installation limitations for in-the-wet construction applications.

Appendix A
Technical Data and Cost Estimates on Fully Revolving Crane Barges



Tub Mounted Rotating Crane

Evaluate Floating Rig Capacities – 360 degree Rotation

Crane Type: Manitowoc 888 Ringer with No. 67B Boom

Diameter of Ringer Assembly (Gross width) =	51.2	feet
Est Height of Center of Gravity (above deck) =	15.2	feet
Estimated Boom Length =	125.0	feet
Maximum allowed boom angle =	70.0	degrees
Est. weight of basic crane (excl CWT & boom) =	573,610	lbs
Estimated total Counterweight (excluding crane) =	1,395,100	lbs
Crane Load (tons, incl load block + rigging) =	451.0	tons
Operating Radius from Center Line crane rotation =	45.0	feet
Calculated Boom Tip Elevation (above deck) =	125.9	feet
Estimated weight on boom =	35,360	lbs

Note: Clearance between ringer and edge of barge (crew walkway) is
14.4 ft to barge side and 5.0 feet to stern of barge

Barge Data

Barge Length overall =	240.0	feet
Barge Width overall =	80.0	feet
Barge Depth overall =	15.0	feet
Navigational Draft =	6.0	feet

Barge Ballasting (optional)

Sponson Dimensions: 100 feet long by 10 feet wide by 13.0 feet deep

Percent Sponson ballasted:	66.0	percent
Added "Free Surface" water ballast (front of Barge) =	30.0	feet (front compartments of barge may be flooded for ballast)
Calculated Draft with crane + sponsor (no load) =	8.1	feet
Calculated Draft with crane and load =	8.8	feet

Calculated Center of Gravity, Buoyancy, BM and GM

Center of Gravity above keel with load (KG) =	23.1	feet above keel
Vert. Dist. to Center of Buoyancy with load (KB) =	4.4	feet
BM (longitudinal), corrected for free water =	386	feet
BM (transverse), corrected for free water =	53	feet
GM (longitudinal), corrected for free water =	367	feet
GM (transverse), corrected for free water =	34	feet

Calculate Machine List

Total Weight (Barge + Crane + Sponson + Load) =	14,000,684	lbs
Longitudinal Listing Moment =	40,590,000	ft-lbs
Transverse Listing Moment =	16,497,360	ft-lbs due to load, including the effects of the sponson counter wt

Machine List if Load over side =	1.98	degrees.	Reach is	5	feet over side of barge
Machine List if Load over stern =	0.45	degrees.	Reach is	14	feet over stern of barge

Lift Capacity controlled by Crane Structural Limitations

Evaluate Floating Rig Capacities – 360 degree Rotation

Crane Type: Manitowoc 888 Ringer with No. 67B Boom

Diameter of Ringer Assembly (Gross width) =	51.2	feet
Est Height of Center of Gravity (above deck) =	15.2	feet
Estimated Boom Length =	125.0	feet
Maximum allowed boom angle =	70.0	degrees
Est. weight of basic crane (excl CWT & boom) =	573,610	lbs
Estimated total Counterweight (excluding crane) =	1,395,100	lbs
Crane Load (tons, incl load block + rigging) =	427.00	tons
Operating Radius from Center Line crane rotation =	50.0	feet
Calculated Boom Tip Elevation (above deck) =	125.9	feet
Estimated weight on boom =	35,360	lbs

Note: Clearance between ringer and edge of barge (crew walkway) is 14.4 ft to barge side and 5.0 feet to stern of barge

Barge Data

Barge Length overall =	240.0	feet
Barge Width overall =	80.0	feet
Barge Depth overall =	15.0	feet
Navigational Draft =	6.0	feet

Barge Ballasting (optional)

Sponson Dimensions: 100 feet long by 10 feet wide by 13.0 feet deep

Percent Sponson ballasted:	71.0	percent
Added "Free Surface" water ballast (front of Barge) =	30.0	feet (front compartments of barge may be flooded for ballast)
Calculated Draft with crane + sponsor (no load) =	8.1	feet
Calculated Draft with crane and load =	8.8	feet

Calculated Center of Gravity, Buoyancy, BM and GM

Center of Gravity above keel with load (KG) =	22.5	feet above keel
Vert. Dist. to Center of Buoyancy with load (KB) =	4.4	feet
BM (longitudinal), corrected for free water =	386	feet
BM (transverse), corrected for free water =	53	feet
GM (longitudinal), corrected for free water =	368	feet
GM (transverse), corrected for free water =	35	feet

Calculate Machine List

Total Weight (Barge + Crane + Sponson + Load) =	13,985,804	lbs
Longitudinal Listing Moment =	42,700,000	ft-lbs
Transverse Listing Moment =	16,782,160	ft-lbs due to load, including the effects of the sponson counter wt

Machine List if Load over side =	1.98	degrees. Reach is	10	feet over side of barge
Machine List if Load over stern =	0.48	degrees. Reach is	19	feet over stern of barge

Lift Capacity controlled by Crane Structural Limitations

Evaluate Floating Rig Capacities – 360 degree Rotation

Crane Type: Manitowoc 888 Ringer with No. 67B Boom

Diameter of Ringer Assembly (Gross width) =	51.2	feet
Est Height of Center of Gravity (above deck) =	15.2	feet
Estimated Boom Length =	125.0	feet
Maximum allowed boom angle =	70.0	degrees
Est. weight of basic crane (excl CWT & boom) =	573,610	lbs
Estimated total Counterweight (excluding crane) =	1,395,100	lbs
Crane Load (tons, incl load block + rigging) =	404.0	tons
Operating Radius from Center Line crane rotation =	55.0	feet
Calculated Boom Tip Elevation (above deck) =	125.9	feet
Estimated weight on boom =	35,360	lbs

Note: Clearance between ringer and edge of barge (crew walkway) is 15.0 ft to barge side and 5.0 feet to stern of barge

Barge Data

Barge Length overall =	240.0	feet
Barge Width overall =	80.0	feet
Barge Depth overall =	15.0	feet
Navigational Draft =	6.0	feet

Barge Ballasting (optional)

Sponson Dimensions: 100 feet long by 10 feet wide by 13.0 feet deep

Percent Sponson ballasted:	75.0	percent
Added "Free Surface" water ballast (front of Barge) =	30.0	feet (front compartments of barge may be flooded for ballast)
Calculated Draft with crane + sponsor (no load) =	8.2	feet
Calculated Draft with crane and load =	8.8	feet

Calculated Center of Gravity, Buoyancy, BM and GM

Center of Gravity above keel with load (KG) =	22.0	feet above keel
Vert. Dist. to Center of Buoyancy with load (KB) =	4.4	feet
BM (longitudinal), corrected for free water =	387	feet
BM (transverse), corrected for free water =	53	feet
GM (longitudinal), corrected for free water =	369	feet
GM (transverse), corrected for free water =	35	feet

Calculate Machine List

Total Weight (Barge + Crane + Sponson + Load) =	13,985,700	lbs
Longitudinal Listing Moment =	44,440,000	ft-lbs
Transverse Listing Moment =	17,062,000	ft-lbs due to load, including the effects of the sponson counter wt

Machine List if Load over side =	1.98	degrees. Reach is	15	feet over side of barge
Machine List if Load over stern =	0.49	degrees. Reach is	24	feet over stern of barge

Lift Capacity controlled by Crane Structural Limitations

Evaluate Floating Rig Capacities – 360 degree Rotation

Crane Type: Manitowoc 888 Ringer with No. 67B Boom

Diameter of Ringer Assembly (Gross width) =	51.2	feet
Est Height of Center of Gravity (above deck) =	15.2	feet
Estimated Boom Length =	125.0	feet
Maximum allowed boom angle =	70.0	degrees
Est. weight of basic crane (excl CWT & boom) =	573,610	lbs
Estimated total Counterweight (excluding crane) =	1,395,100	lbs
Crane Load (tons, incl load block + rigging) =	384.0	tons
Operating Radius from Center Line crane rotation =	60.0	feet
Calculated Boom Tip Elevation (above deck) =	125.9	feet
Estimated weight on boom =	35,360	lbs

Note: Clearance between ringer and edge of barge (crew walkway) is
15.0 ft to barge side and 5.0 feet to stern of barge

Barge Data

Barge Length overall =	240.0	feet
Barge Width overall =	80.0	feet
Barge Depth overall =	15.0	feet
Navigational Draft =	6.0	feet

Barge Ballasting (optional)

Sponson Dimensions: 100 feet long by 10 feet wide by 13.0 feet deep

Percent Sponson ballasted:	79.0	percent
Added "Free Surface" water ballast (front of Barge) =	30.0	feet (front compartments of barge may be flooded for ballast)
Calculated Draft with crane + sponsor (no load) =	8.2	feet
Calculated Draft with crane and load =	8.8	feet

Calculated Center of Gravity, Buoyancy, BM and GM

Center of Gravity above keel with load (KG) =	21.5	feet above keel
Vert. Dist. to Center of Buoyancy with load (KB) =	4.4	feet
BM (longitudinal), corrected for free water =	387	feet
BM (transverse), corrected for free water =	53	feet
GM (longitudinal), corrected for free water =	370	feet
GM (transverse), corrected for free water =	36	feet

Calculate Machine List

Total Weight (Barge + Crane + Sponson + Load) =	13,943,596	lbs
Longitudinal Listing Moment =	46,080,000	ft-lbs
Transverse Listing Moment =	17,241,840	ft-lbs due to load, including the effects of the sponson counter wt

Machine List if Load over side =	1.98	degrees. Reach is	20	feet over side of barge
Machine List if Load over stern =	0.51	degrees. Reach is	29	feet over stern of barge

Lift Capacity controlled by Crane Structural Limitations

Evaluate Floating Rig Capacities – 360 degree Rotation

Crane Type: Manitowoc 888 Ringer with No. 67B Boom

Diameter of Ringer Assembly (Gross width) =	51.2	feet
Est Height of Center of Gravity (above deck) =	15.2	feet
Estimated Boom Length =	125.0	feet
Maximum allowed boom angle =	70.0	degrees
Est. weight of basic crane (excl CWT & boom) =	573,610	lbs
Estimated total Counterweight (excluding crane) =	1,395,100	lbs
Crane Load (tons, incl load block + rigging) =	366.0	tons
Operating Radius from Center Line crane rotation =	65.0	feet
Calculated Boom Tip Elevation (above deck) =	125.9	feet
Estimated weight on boom =	35,360	lbs

Note: Clearance between ringer and edge of barge (crew walkway) is
14.4 ft to barge side and 5.0 feet to stern of barge

Barge Data

Barge Length overall =	240.0	feet
Barge Width overall =	80.0	feet
Barge Depth overall =	15.0	feet
Navigational Draft =	6.0	feet

Barge Ballasting (optional)

Sponson Dimensions: 100 feet long by 10 feet wide by 13.0 feet deep

Percent Sponson ballasted:	82.0	percent
Added "Free Surface" water ballast (front of Barge) =	30.0	feet (front compartments of barge may be flooded for ballast)
Calculated Draft with crane + sponsor (no load) =	8.2	feet
Calculated Draft with crane and load =	8.8	feet

Calculated Center of Gravity, Buoyancy, BM and GM

Center of Gravity above keel with load (KG) =	21.0	feet above keel
Vert. Dist. to Center of Buoyancy with load (KB) =	4.4	feet
BM (longitudinal), corrected for free water =	387	feet
BM (transverse), corrected for free water =	53	feet
GM (longitudinal), corrected for free water =	371	feet
GM (transverse), corrected for free water =	36	feet

Calculate Machine List

Total Weight (Barge + Crane + Sponson + Load) =	13,920,268	lbs
Longitudinal Listing Moment =	47,580,000	ft-lbs
Transverse Listing Moment =	17,646,720	ft-lbs due to load, including the effects of the sponson counter wt

Machine List if Load over side =	2.00	degrees. Reach is	25	feet over side of barge
Machine List if Load over stern =	0.53	degrees. Reach is	34	feet over stern of barge

Lift Capacity controlled by Crane Structural Limitations

Evaluate Floating Rig Capacities – 360 degree Rotation

Crane Type: Manitowoc 888 Ringer with No. 67B Boom

Diameter of Ringer Assembly (Gross width) =	51.2	feet
Est Height of Center of Gravity (above deck) =	15.2	feet
Estimated Boom Length =	125.0	feet
Maximum allowed boom angle =	70.0	degrees
Est. weight of basic crane (excl CWT & boom) =	573,610	lbs
Estimated total Counterweight (excluding crane) =	1,395,100	lbs
Crane Load (tons, incl load block + rigging) =	350.0	tons
Operating Radius from Center Line crane rotation =	70.0	feet
Calculated Boom Tip Elevation (above deck) =	125.9	feet
Estimated weight on boom =	35,360	lbs

Note: Clearance between ringer and edge of barge (crew walkway) is
15.0 ft to barge side and 5.0 feet to stern of barge

Barge Data

Barge Length overall =	240.0	feet
Barge Width overall =	80.0	feet
Barge Depth overall =	15.0	feet
Navigational Draft =	6.0	feet

Barge Ballasting (optional)

Sponson Dimensions: 100 feet long by 10 feet wide by 13.0 feet deep

Percent Sponson ballasted:	85.0	percent
Added "Free Surface" water ballast (front of Barge) =	30.0	feet (front compartments of barge may be flooded for ballast)
Calculated Draft with crane + sponsor (no load) =	8.2	feet
Calculated Draft with crane and load =	8.8	feet

Calculated Center of Gravity, Buoyancy, BM and GM

Center of Gravity above keel with load (KG) =	20.7	feet above keel
Vert. Dist. to Center of Buoyancy with load (KB) =	4.4	feet
BM (longitudinal), corrected for free water =	388	feet
BM (transverse), corrected for free water =	53	feet
GM (longitudinal), corrected for free water =	371	feet
GM (transverse), corrected for free water =	37	feet

Calculate Machine List

Total Weight (Barge + Crane + Sponson + Load) =	13,904,940	lbs
Longitudinal Listing Moment =	49,000,000	ft-lbs
Transverse Listing Moment =	17,971,600	ft-lbs due to load, including the effects of the sponson counter wt

Machine List if Load over side =	2.01	degrees. Reach is	30	feet over side of barge
Machine List if Load over stern =	0.54	degrees. Reach is	39	feet over stern of barge

Lift Capacity controlled by Crane Structural Limitations

Evaluate Floating Rig Capacities – 360 degree Rotation

Crane Type: Manitowoc 888 Ringer with No. 67B Boom

Diameter of Ringer Assembly (Gross width) =	51.2	feet
Est Height of Center of Gravity (above deck) =	15.2	feet
Estimated Boom Length =	125.0	feet
Maximum allowed boom angle =	70.0	degrees
Est. weight of basic crane (excl CWT & boom) =	573,610	lbs
Estimated total Counterweight (excluding crane) =	1,395,100	lbs
Crane Load (tons, incl load block + rigging) =	335.0	tons
Operating Radius from Center Line crane rotation =	75.0	feet
Calculated Boom Tip Elevation (above deck) =	125.9	feet
Estimated weight on boom =	35,360	lbs

Note: Clearance between ringer and edge of barge (crew walkway) is 15.0 ft to barge side and 5.0 feet to stern of barge

Barge Data

Barge Length overall =	240.0	feet
Barge Width overall =	80.0	feet
Barge Depth overall =	15.0	feet
Navigational Draft =	6.0	feet

Barge Ballasting (optional)

Sponson Dimensions: 100 feet long by 10 feet wide by 13.0 feet deep

Percent Sponson ballasted:	88.0	percent
Added "Free Surface" water ballast (front of Barge) =	30.0	feet (front compartments of barge may be flooded for ballast)
Calculated Draft with crane + sponsor (no load) =	8.2	feet
Calculated Draft with crane and load =	8.8	feet

Calculated Center of Gravity, Buoyancy, BM and GM

Center of Gravity above keel with load (KG) =	20.3	feet above keel
Vert. Dist. to Center of Buoyancy with load (KB) =	4.4	feet
BM (longitudinal), corrected for free water =	388	feet
BM (transverse), corrected for free water =	53	feet
GM (longitudinal), corrected for free water =	372	feet
GM (transverse), corrected for free water =	37	feet

Calculate Machine List

Total Weight (Barge + Crane + Sponson + Load) =	13,893,612	lbs
Longitudinal Listing Moment =	50,250,000	ft-lbs
Transverse Listing Moment =	18,126,480	ft-lbs due to load, including the effects of the sponson counter wt

Machine List if Load over side =	2.01	degrees. Reach is	35	feet over side of barge
Machine List if Load over stern =	0.56	degrees. Reach is	44	feet over stern of barge

Lift Capacity controlled by Crane Structural Limitations

Evaluate Floating Rig Capacities – 360 degree Rotation

Crane Type: Manitowoc 888 Ringer with No. 67B Boom

Diameter of Ringer Assembly (Gross width) =	51.2	feet
Est Height of Center of Gravity (above deck) =	15.2	feet
Estimated Boom Length =	125.0	feet
Maximum allowed boom angle =	70.0	degrees
Est. weight of basic crane (excl CWT & boom) =	573,610	lbs
Estimated total Counterweight (excluding crane) =	1,395,100	lbs
Crane Load (tons, incl load block + rigging) =	321.0	tons
Operating Radius from Center Line crane rotation =	80.0	feet
Calculated Boom Tip Elevation (above deck) =	125.9	feet
Estimated weight on boom =	35,360	lbs

Note: Clearance between ringer and edge of barge (crew walkway) is
15.0 ft to barge side and 5.0 feet to stern of barge

Barge Data

Barge Length overall =	240.0	feet
Barge Width overall =	80.0	feet
Barge Depth overall =	15.0	feet
Navigational Draft =	6.0	feet

Barge Ballasting (optional)

Sponson Dimensions: 100 feet long by 10 feet wide by 13.0 feet deep

Percent Sponson ballasted:	91.0	percent
Added "Free Surface" water ballast (front of Barge) =	30.0	feet (front compartments of barge may be flooded for ballast)
Calculated Draft with crane + sponsor (no load) =	8.3	feet
Calculated Draft with crane and load =	8.8	feet

Calculated Center of Gravity, Buoyancy, BM and GM

Center of Gravity above keel with load (KG) =	19.9	feet above keel
Vert. Dist. to Center of Buoyancy with load (KB) =	4.4	feet
BM (longitudinal), corrected for free water =	388	feet
BM (transverse), corrected for free water =	53	feet
GM (longitudinal), corrected for free water =	372	feet
GM (transverse), corrected for free water =	38	feet

Calculate Machine List

Total Weight (Barge + Crane + Sponson + Load) =	13,886,284	lbs
Longitudinal Listing Moment =	51,360,000	ft-lbs
Transverse Listing Moment =	18,141,360	ft-lbs due to load, including the effects of the sponson counter wt

Machine List if Load over side =	2.00	degrees. Reach is	40	feet over side of barge
Machine List if Load over stern =	0.57	degrees. Reach is	49	feet over stern of barge

Lift Capacity controlled by Crane Structural Limitations

Evaluate Floating Rig Capacities – 360 degree Rotation

Crane Type: Manitowoc 888 Ringer with No. 67B Boom

Diameter of Ringer Assembly (Gross width) =	51.2	feet
Est Height of Center of Gravity (above deck) =	15.2	feet
Estimated Boom Length =	125.0	feet
Maximum allowed boom angle =	70.0	degrees
Est. weight of basic crane (excl CWT & boom) =	573,610	lbs
Estimated total Counterweight (excluding crane) =	1,395,100	lbs
Crane Load (tons, incl load block + rigging) =	301.0	tons
Operating Radius from Center Line crane rotation =	85.0	feet
Calculated Boom Tip Elevation (above deck) =	125.9	feet
Estimated weight on boom =	35,360	lbs

Note: Clearance between ringer and edge of barge (crew walkway) is 15.0 ft to barge side and 5.0 feet to stern of barge

Barge Data

Barge Length overall =	240.0	feet
Barge Width overall =	80.0	feet
Barge Depth overall =	15.0	feet
Navigational Draft =	6.0	feet

Barge Ballasting (optional)

Sponson Dimensions: 100 feet long by 10 feet wide by 13.0 feet deep

Percent Sponson ballasted:	90.0	percent
Added "Free Surface" water ballast (front of Barge) =	30.0	feet (front compartments of barge may be flooded for ballast)
Calculated Draft with crane + sponsor (no load) =	8.3	feet
Calculated Draft with crane and load =	8.8	feet

Calculated Center of Gravity, Buoyancy, BM and GM

Center of Gravity above keel with load (KG) =	19.5	feet above keel
Vert. Dist. to Center of Buoyancy with load (KB) =	4.4	feet
BM (longitudinal), corrected for free water =	390	feet
BM (transverse), corrected for free water =	53	feet
GM (longitudinal), corrected for free water =	375	feet
GM (transverse), corrected for free water =	38	feet

Calculate Machine List

Total Weight (Barge + Crane + Sponson + Load) =	13,790,060	lbs
Longitudinal Listing Moment =	51,170,000	ft-lbs
Transverse Listing Moment =	18,316,400	ft-lbs due to load, including the effects of the sponson counter wt

Machine List if Load over side =	1.99	degrees. Reach is	45	feet over side of barge
Machine List if Load over stern =	0.57	degrees. Reach is	54	feet over stern of barge

Lift Capacity controlled by Crane Structural Limitations

Evaluate Floating Rig Capacities – 360 degree Rotation

Crane Type: Manitowoc 888 Ringer with No. 67B Boom

Diameter of Ringer Assembly (Gross width) =	51.2	feet
Est Height of Center of Gravity (above deck) =	15.2	feet
Estimated Boom Length =	125.0	feet
Maximum allowed boom angle =	70.0	degrees
Est. weight of basic crane (excl CWT & boom) =	573,610	lbs
Estimated total Counterweight (excluding crane) =	1,395,100	lbs
Crane Load (tons, incl load block + rigging) =	284.0	tons
Operating Radius from Center Line crane rotation =	90.0	feet
Calculated Boom Tip Elevation (above deck) =	125.9	feet
Estimated weight on boom =	35,360	lbs

Note: Clearance between ringer and edge of barge (crew walkway) is
15.0 ft to barge side and 5.0 feet to stern of barge

Barge Data

Barge Length overall =	240.0	feet
Barge Width overall =	80.0	feet
Barge Depth overall =	15.0	feet
Navigational Draft =	6.0	feet

Barge Ballasting (optional)

Sponson Dimensions: 100 feet long by 10 feet wide by 13.0 feet deep

Percent Sponson ballasted:	90.0	percent
Added "Free Surface" water ballast (front of Barge) =	30.0	feet (front compartments of barge may be flooded for ballast)
Calculated Draft with crane + sponsor (no load) =	8.3	feet
Calculated Draft with crane and load =	8.7	feet

Calculated Center of Gravity, Buoyancy, BM and GM

Center of Gravity above keel with load (KG) =	19.1	feet above keel
Vert. Dist. to Center of Buoyancy with load (KB) =	4.4	feet
BM (longitudinal), corrected for free water =	391	feet
BM (transverse), corrected for free water =	53	feet
GM (longitudinal), corrected for free water =	376	feet
GM (transverse), corrected for free water =	39	feet

Calculate Machine List

Total Weight (Barge + Crane + Sponson + Load) =	13,722,060	lbs
Longitudinal Listing Moment =	51,120,000	ft-lbs
Transverse Listing Moment =	18,266,400	ft-lbs due to load, including the effects of the sponson counter wt

Machine List if Load over side =	1.97	degrees. Reach is	50	feet over side of barge
Machine List if Load over stern =	0.57	degrees. Reach is	59	feet over stern of barge

Lift Capacity controlled by Crane Structural Limitations

Evaluate Floating Rig Capacities – 360 degree Rotation

Crane Type: Manitowoc 888 Ringer with No. 67B Boom

Diameter of Ringer Assembly (Gross width) =	51.2	feet
Est Height of Center of Gravity (above deck) =	15.2	feet
Estimated Boom Length =	125.0	feet
Maximum allowed boom angle =	70.0	degrees
Est. weight of basic crane (excl CWT & boom) =	573,610	lbs
Estimated total Counterweight (excluding crane) =	1,395,100	lbs
Crane Load (tons, incl load block + rigging) =	268.0	tons
Operating Radius from Center Line crane rotation =	95.0	feet
Calculated Boom Tip Elevation (above deck) =	125.9	feet
Estimated weight on boom =	35,360	lbs

Note: Clearance between ringer and edge of barge (crew walkway) is
14.4 ft to barge side and 5.0 feet to stern of barge

Barge Data

Barge Length overall =	240.0	feet
Barge Width overall =	80.0	feet
Barge Depth overall =	15.0	feet
Navigational Draft =	6.0	feet

Barge Ballasting (optional)

Sponson Dimensions: 100 feet long by 10 feet wide by 13.0 feet deep

Percent Sponson ballasted:	89.0	percent
Added "Free Surface" water ballast (front of Barge) =	30.0	feet (front compartments of barge may be flooded for ballast)
Calculated Draft with crane + sponsor (no load) =	8.2	feet
Calculated Draft with crane and load =	8.7	feet

Calculated Center of Gravity, Buoyancy, BM and GM

Center of Gravity above keel with load (KG) =	18.7	feet above keel
Vert. Dist. to Center of Buoyancy with load (KB) =	4.3	feet
BM (longitudinal), corrected for free water =	393	feet
BM (transverse), corrected for free water =	54	feet
GM (longitudinal), corrected for free water =	378	feet
GM (transverse), corrected for free water =	39	feet

Calculate Machine List

Total Weight (Barge + Crane + Sponson + Load) =	13,641,836	lbs
Longitudinal Listing Moment =	50,920,000	ft-lbs
Transverse Listing Moment =	18,431,440	ft-lbs due to load, including the effects of the sponson counter wt

Machine List if Load over side =	1.97	degrees. Reach is	55	feet over side of barge
Machine List if Load over stern =	0.57	degrees. Reach is	64	feet over stern of barge

Lift Capacity controlled by Crane Structural Limitations

Evaluate Floating Rig Capacities – 360 degree Rotation

Crane Type: Manitowoc 888 Ringer with No. 67B Boom

Diameter of Ringer Assembly (Gross width) =	51.2	feet
Est Height of Center of Gravity (above deck) =	15.2	feet
Estimated Boom Length =	125.0	feet
Maximum allowed boom angle =	70.0	degrees
Est. weight of basic crane (excl CWT & boom) =	573,610	lbs
Estimated total Counterweight (excluding crane) =	1,395,100	lbs
Crane Load (tons, incl load block + rigging) =	254.0	tons
Operating Radius from Center Line crane rotation =	100.0	feet
Calculated Boom Tip Elevation (above deck) =	125.9	feet
Estimated weight on boom =	35,360	lbs

Note: Clearance between ringer and edge of barge (crew walkway) is
14.4 ft to barge side and 5.0 feet to stern of barge

Barge Data

Barge Length overall =	240.0	feet
Barge Width overall =	80.0	feet
Barge Depth overall =	15.0	feet
Navigational Draft =	6.0	feet

Barge Ballasting (optional)

Sponson Dimensions: 100 feet long by 10 feet wide by 13.0 feet deep

Percent Sponson ballasted:	88.0	percent
Added "Free Surface" water ballast (front of Barge) =	30.0	feet (front compartments of barge may be flooded for ballast)
Calculated Draft with crane + sponsor (no load) =	8.2	feet
Calculated Draft with crane and load =	8.7	feet

Calculated Center of Gravity, Buoyancy, BM and GM

Center of Gravity above keel with load (KG) =	18.7	feet above keel
Vert. Dist. to Center of Buoyancy with load (KB) =	4.3	feet
BM (longitudinal), corrected for free water =	394	feet
BM (transverse), corrected for free water =	54	feet
GM (longitudinal), corrected for free water =	380	feet
GM (transverse), corrected for free water =	40	feet

Calculate Machine List

Total Weight (Barge + Crane + Sponson + Load) =	13,569,612	lbs
Longitudinal Listing Moment =	50,800,000	ft-lbs
Transverse Listing Moment =	18,676,480	ft-lbs due to load, including the effects of the sponson counter wt

Machine List if Load over side =	1.98	degrees. Reach is	60	feet over side of barge
Machine List if Load over stem =	0.56	degrees. Reach is	69	feet over stern of barge

Lift Capacity controlled by Crane Structural Limitations

Evaluate Floating Rig Capacities – 360 degree Rotation

Crane Type: Manitowoc 888 Ringer with No. 67B Boom

Diameter of Ringer Assembly (Gross width) =	51.2	feet
Est Height of Center of Gravity (above deck) =	15.2	feet
Estimated Boom Length =	125.0	feet
Maximum allowed boom angle =	70.0	degrees
Est. weight of basic crane (excl CWT & boom) =	573,610	lbs
Estimated total Counterweight (excluding crane) =	1,395,100	lbs
Crane Load (tons, incl load block + rigging) =	229.0	tons
Operating Radius from Center Line crane rotation =	110.0	feet
Calculated Boom Tip Elevation (above deck) =	125.9	feet
Estimated weight on boom =	35,360	lbs

Note: Clearance between ringer and edge of barge (crew walkway) is
14.4 ft to barge side and 5.0 feet to stern of barge

Barge Data

Barge Length overall =	240.0	feet
Barge Width overall =	80.0	feet
Barge Depth overall =	15.0	feet
Navigational Draft =	6.0	feet

Barge Ballasting (optional)

Sponson Dimensions: 100 feet long by 10 feet wide by 13.0 feet deep

Percent Sponson ballasted:	86.0	percent
Added "Free Surface" water ballast (front of Barge) =	30.0	feet (front compartments of barge may be flooded for ballast)
Calculated Draft with crane + sponsor (no load) =	8.2	feet
Calculated Draft with crane and load =	8.6	feet

Calculated Center of Gravity, Buoyancy, BM and GM

Center of Gravity above keel with load (KG) =	17.8	feet above keel
Vert. Dist. to Center of Buoyancy with load (KB) =	4.3	feet
BM (longitudinal), corrected for free water =	396	feet
BM (transverse), corrected for free water =	54	feet
GM (longitudinal), corrected for free water =	383	feet
GM (transverse), corrected for free water =	41	feet

Calculate Machine List

Total Weight (Barge + Crane + Sponson + Load) =	13,437,060	lbs
Longitudinal Listing Moment =	50,380,000	ft-lbs
Transverse Listing Moment =	18,986,560	ft-lbs due to load, including the effects of the sponson counter wt

Machine List if Load over side =	1.99	degrees. Reach is	70	feet over side of barge
Machine List if Load over stern =	0.56	degrees. Reach is	79	feet over stern of barge

Lift Capacity controlled by Crane Structural Limitations

Evaluate Floating Rig Capacities – 360 degree Rotation

Crane Type: Manitowoc 888 Ringer with No. 67B Boom

Diameter of Ringer Assembly (Gross width) =	51.2	feet
Est Height of Center of Gravity (above deck) =	15.2	feet
Estimated Boom Length =	125.0	feet
Maximum allowed boom angle =	70.0	degrees
Est. weight of basic crane (excl CWT & boom) =	573,610	lbs
Estimated total Counterweight (excluding crane) =	1,395,100	lbs
Crane Load (tons, incl load block + rigging) =	425.0	tons
Operating Radius from Center Line crane rotation =	45.0	feet
Calculated Boom Tip Elevation (above deck) =	125.9	feet
Estimated weight on boom =	35,360	lbs

Note: Clearance between ringer and edge of barge (crew walkway) is 14.4 ft to barge side and 5.0 feet to stern of barge

Barge Data

Barge Length overall =	240.0	feet
Barge Width overall =	80.0	feet
Barge Depth overall =	15.0	feet
Navigational Draft =	6.0	feet

Barge Ballasting (optional)

Sponson Dimensions: 100 feet long by 10 feet wide by 13.0 feet deep

Percent Sponson ballasted:	0.0	percent
Added "Free Surface" water ballast (front of Barge) =	0.0	feet (front compartments of barge may be flooded for ballast)
Calculated Draft with crane + sponsor (no load) =	7.6	feet
Calculated Draft with crane and load =	8.4	feet

Calculated Center of Gravity, Buoyancy, BM and GM

Center of Gravity above keel with load (KG) =	23.9	feet above keel
Vert. Dist. to Center of Buoyancy with load (KB) =	4.2	feet
BM (longitudinal), corrected for free water =	572	feet
BM (transverse), corrected for free water =	64	feet
GM (longitudinal), corrected for free water =	552	feet
GM (transverse), corrected for free water =	44	feet

Calculate Machine List

Total Weight (Barge + Crane + Sponson + Load) =	12,933,900	lbs
Longitudinal Listing Moment =	40,680,000	ft-lbs

Machine List if Load over side = 0.33 degrees. Reach is 14 feet over side of barge

Lift Capacity controlled by Crane Structural Limitations

Appendix A

Cost Analysis, Purchasing Option of Manitowoc 888 Crane Barge (1 Year Duration, 100% Usage)

Assumed duration of heavy lift crane use	1	years
Months out of each year crane operates	12	months per year
Cost of capital	8.0	percent
Sales Tax Rate	7.5	percent
Depreciation Rate, per year	5.0	percent (depreciation is generally low on large lift cranes - they can even appreciate)
No. of truck loads to move crane	60.0	each (there are 49 loads of just counterweight and ringer. Allow 10 more for crane and boom)
No. of shifts to Mob or Demob crane	6.0	each

Cost to Purchase Crane Barge

Purchase cost of Manitowoc 888 Crane and Boom (new) =	$	1,650,000	(suggested price from Manitowoc)
Purchase Ringer Attachment for 888 (new) =	$	3,215,000	(suggested price from Manitowoc)
Purchase barge, 240' x 80' x 15' (used, w/mooring equip) =	$	3,000,000	(suggested price from Bisso Marine)
Total Purchase Cost =	$	7,865,000	
Cost of Capital for duration of lift crane use	$	629,200	
Sales Tax on purchase	$	589,875	
Crane Depreciation (use 5% per year)	$	243,250	
Barge Depreciation (say 20% lump sum)	$	600,000	
Total Ownership Cost =	*$*	*2,062,325*	

Cost to Mobilize and De-Mobilize Crane Once

Cost to Transport Crane to Site	$	-	(included in purchase cost)
Cost to Transport Crane from Site	$	96,000	(16 hrs trucking per load x $100/hour trucking cost)
Cost to deliver barge to site	$	-	(included in purchase cost)
Cost to deliver barge from site	$	75,000	(say tug for 1 week at $10,000 per shift, plus $25,000 general expenses)
Cost to assemble Crane on site	$	45,000	(assume $7,500/shift to assemble crane - includes cost of 4100 helper crane)
Cost to dis-assemble Crane on site	$	45,000	(assume $7,500/shift to assemble crane - includes cost of 4100 helper crane)
Access trestle (100' x 50' @ $20/sf) to assmbl crane	$	100,000	
Total Mob/Demob Cost =	*$*	*361,000*	

Cost to Operate Crane

Operators	1	ea x	1,920	hrs =	$	80,640	(Avg hrly labor cost is $42/hour)
Oilers	1	ea x	1,920	hrs =	$	61,440	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	2	ea x	3,840	hrs =	$	122,880	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1	ea x	1,920	hrs =	$	230,400	(assume $20/hour fuel, oil, and grease pluse $40/hour in parts and mechanic time)
Total Operations Cost =					*$*	*495,360*	

Equipment Rental Cost =	$	2,062,325	
Mobilization & De-mobilization =	$	361,000	(cost is for 1 mob and demob since the crane is purchased and remains on job)
Operating Costs =	$	495,360	
Total Cost =	$	2,918,685	

Appendix A

Cost Analysis, Purchasing Option of Manitowoc 888 Crane Barge (2 Year Duration, 50% Usage)

Assumed duration of heavy lift crane use	2	years
Months out of each year crane operates	6	months per year
Cost of capital	8.0	percent
Sales Tax Rate	7.5	percent
Depreciation Rate, per year	5.0	percent (depreciation is generally low on large lift cranes - they can even appreciate)
No. of truck loads to move crane	60.0	each (there are 49 loads of just counterweight and ringer. Allow 10 more for crane and boom)
No. of shifts to Mob or Demob crane	6.0	each

Cost to Purchase Crane Barge

Purchase cost of Manitowoc 888 Crane and Boom (new) =	$	1,650,000	(suggested price from Manitowoc)
Purchase Ringer Attachment for 888 (new) =	$	3,215,000	(suggested price from Manitowoc)
Purchase barge, 240' x 80' x 15' (used, w/mooring equip) =	$	3,000,000	(suggested price from Bisso Marine)
Total Purchase Cost =	$	7,865,000	
Cost of Capital for duration of lift crane use	$	1,308,736	
Sales Tax on purchase	$	589,875	
Crane Depreciation (use 5% per year)	$	486,500	
Barge Depreciation (say 20% lump sum)	$	600,000	
Total Ownership Cost =	*$*	*2,985,111*	

Cost to Mobilize and De-Mobilize Crane Once

Cost to Transport Crane to Site	$	-	(included in purchase cost)
Cost to Transport Crane from Site	$	96,000	(16 hrs trucking per load x $100/hour trucking cost)
Cost to deliver barge to site	$	-	(included in purchase cost)
Cost to deliver barge from site	$	75,000	(say tug for 1 week at $10,000 per shift, plus $25,000 general expenses)
Cost to assemble Crane on site	$	45,000	(assume $7,500/shift to assemble crane - includes cost of 4100 helper crane)
Cost to dis-assemble Crane on site	$	45,000	(assume $7,500/shift to assemble crane - includes cost of 4100 helper crane)
Access trestle (100' x 50' @ $20/sf) to assmbl crane	$	100,000	
Total Mob/Demob Cost =	*$*	*361,000*	

Cost to Operate Crane

Operators	1	ea x	1,920	hrs =	$	80,640	(Avg hrly labor cost is $42/hour)
Oilers	1	ea x	1,920	hrs =	$	61,440	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	2	ea x	3,840	hrs =	$	122,880	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1	ea x	1,920	hrs =	$	230,400	(assume $20/hour fuel, oil, and grease pluse $40/hour in parts and mechanic time)
Total Operations Cost =					*$*	*495,360*	

Equipment Rental Cost =	$	2,985,111	
Mobilization & De-mobilization =	$	361,000	(cost is for 1 mob and demob since the crane is purchased and remains on job)
Operating Costs =	$	495,360	
Total Cost =	$	3,841,471	

Appendix A

Cost Analysis, Purchasing Option of Manitowoc 888 Crane Barge (3 Year Duration, 50% Usage)

Assumed duration of heavy lift crane use	3	years
Months out of each year crane operates	6	months per year
Cost of capital	8.0	percent
Sales Tax Rate	7.5	percent
Depreciation Rate, per year	5.0	percent (depreciation is generally low on large lift cranes - they can even appreciate)
No. of truck loads to move crane	60.0	each (there are 49 loads of just counterweight and ringer. Allow 10 more for crane and boom)
No. of shifts to Mob or Demob crane	6.0	each

Cost to Purchase Crane Barge

Purchase cost of Manitowoc 888 Crane and Boom (new) =	$	1,650,000	(suggested price from Manitowoc)
Purchase Ringer Attachment for 888 (new) =	$	3,215,000	(suggested price from Manitowoc)
Purchase barge, 240' x 80' x 15' (used, w/mooring equip) =	$	3,000,000	(suggested price from Bisso Marine)
Total Purchase Cost =	$	7,865,000	
Cost of Capital for duration of lift crane use	$	2,042,635	
Sales Tax on purchase	$	589,875	
Crane Depreciation (use 5% per year)	$	729,750	
Barge Depreciation (say 20% lump sum)	$	600,000	
Total Ownership Cost =	*$*	*3,962,260*	

Cost to Mobilize and De-Mobilize Crane Once

Cost to Transport Crane to Site	$	-	(included in purchase cost)
Cost to Transport Crane from Site	$	96,000	(16 hrs trucking per load x $100/hour trucking cost)
Cost to deliver barge to site	$	-	(included in purchase cost)
Cost to deliver barge from site	$	75,000	(say tug for 1 week at $10,000 per shift, plus $25,000 general expenses)
Cost to assemble Crane on site	$	45,000	(assume $7,500/shift to assemble crane - includes cost of 4100 helper crane)
Cost to dis-assemble Crane on site	$	45,000	(assume $7,500/shift to assemble crane - includes cost of 4100 helper crane)
Access trestle (100' x 50' @ $20/sf) to assmbl crane	$	100,000	
Total Mob/Demob Cost =	*$*	*361,000*	

Cost to Operate Crane

Operators	1	ea x	2,880	hrs =	$	120,960	(Avg hrly labor cost is $42/hour)
Oilers	1	ea x	2,880	hrs =	$	92,160	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	2	ea x	5,760	hrs =	$	184,320	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1	ea x	2,880	hrs =	$	345,600	(assume $20/hour fuel, oil, and grease pluse $40/hour in parts and mechanic time)
Total Operations Cost =					*$*	*743,040*	

Equipment Rental Cost =	$	3,962,260	
Mobilization & De-mobilization =	$	361,000	(cost is for 1 mob and demob since the crane is purchased and remains on job)
Operating Costs =	$	743,040	
Total Cost =	$	5,066,300	

Appendix A

Cost Analysis, Leasing Option of Manitowoc 888 Crane Barge (1 Year Duration, 100% Usage)

Assumed duration of heavy lift crane	1	years	
Months out of each year crane operates	12.00	months per year	(minimum 6 month rental period)
Number of Mobilziations/De-mobs	1	each	
Cost of capital	8.0	percent	
Sales Tax Rate	7.5	percent	
No. of truck loads to move crane	60.0	each (there are 49 loads of just counterweight and ringer. Allow 10 more for crane and boom)	
No. of shifts to Mob or Demob crane	6.0	each	

Cost to Rent/Lease Crane

Rental Cost of Crane and Ringer during operating period	$	1,320,000	(Manitowoc suggested $110,000/mo., minimum 6 mo rental applies)
Rental Cost of Barge during operation	$	900,000	(assume 240' x 80' x 15' barge is $3,000,000 new. Allow 2.5% per month lease.)
Rental Cost of Crane and Ringer during standby period	$	-	(allow 50% standby rent on idle equipment)
Rental Cost of Barge during standby	$	-	(allow 50% standby rent on idle equipment)
Sales Tax on rent	$	166,500	
Total leasing Cost =	*$*	*2,386,500*	

Cost to Mobilize and De-Mobilize Crane Once

Cost to Transport Crane to Site	$	96,000	(16 hrs trucking per load x $100/hour trucking cost)
Cost to Transport Crane from Site	$	96,000	(16 hrs trucking per load x $100/hour trucking cost)
Cost to deliver barge to site	$	75,000	(say tug for 5 shifts at $10,000 per shift, plus $25,000 general expenses)
Cost to deliver barge from site	$	75,000	(say tug for 5 shifts at $10,000 per shift, plus $25,000 general expenses)
Cost to assemble Crane on site	$	36,000	(assume $6,000/shift to assemble crane - includes cost of 4100 helper crane)
Cost to dis-assemble Crane on site	$	36,000	(assume $6,000/shift to assemble crane - includes cost of 4100 helper crane)
Access trestle (100' x 50' @ $20/sf) to assmbl crane	$	100,000	
Mobilization/Demob Cost =	*$*	*514,000*	

Cost to Operate Crane

Operators	1	each	1,920	hrs =	$	80,640	(Avg hrly labor cost is $42/hour)
Oilers	1	each	1,920	hrs =	$	80,640	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	2	each	3,840	hrs =	$	161,280	(Avg hrly labor cost is $32/hour)
Operating Cost (fuel, oil, grease)	1	each	1,920	hrs =	$	38,400	(assume $20/hour fuel, oil, and grease. Lessor pays for repairs)
Total Operations Cost =					*$*	*360,960*	

Equipment Rental Cost =	2,386,500	
Mobilization & De-mobilization =	514,000	(cost is for 1 mobs and demobs)
Operating Costs =	360,960	
Total Crane Costs =	3,261,460	

Appendix A

Cost Analysis, Leasing Option of Manitowoc 888 Crane Barge (2 Year Duration, 50% Usage)

Assumed duration of heavy lift crane	2	years	
Months out of each year crane operates	6.00	months per year	(minimum 6 month rental period)
Number of Mobilziations/De-mobs	2	each	
Cost of capital	8.0	percent	
Sales Tax Rate	7.5	percent	
No. of truck loads to move crane	60.0	each (there are 49 loads of just counterweight and ringer. Allow 10 more for crane and boom)	
No. of shifts to Mob or Demob crane	6.0	each	

Cost to Rent/Lease Crane

Rental Cost of Crane and Ringer during operating period	$	1,320,000	(Manitowoc suggested $110,000/mo., minimum 6 mo rental applies)
Rental Cost of Barge during operation	$	900,000	(assume 240' x 80' x 15' barge is $3,000,000 new. Allow 2.5% per month lease.)
Rental Cost of Crane and Ringer during standby period	$	-	(allow 50% standby rent on idle equipment)
Rental Cost of Barge during standby	$	-	(allow 50% standby rent on idle equipment)
Sales Tax on rent	$	166,500	
Total leasing Cost =	*$*	*2,386,500*	

Cost to Mobilize and De-Mobilize Crane Once

Cost to Transport Crane to Site	$	96,000	(16 hrs trucking per load x $100/hour trucking cost)
Cost to Transport Crane from Site	$	96,000	(16 hrs trucking per load x $100/hour trucking cost)
Cost to deliver barge to site	$	75,000	(say tug for 5 shifts at $10,000 per shift, plus $25,000 general expenses)
Cost to deliver barge from site	$	75,000	(say tug for 5 shifts at $10,000 per shift, plus $25,000 general expenses)
Cost to assemble Crane on site	$	36,000	(assume $6,000/shift to assemble crane - includes cost of 4100 helper crane)
Cost to dis-assemble Crane on site	$	36,000	(assume $6,000/shift to assemble crane - includes cost of 4100 helper crane)
Access trestle (100' x 50' @ $20/sf) to assmbl crane	$	100,000	
Mobilization/Demob Cost =	*$*	*514,000*	

Cost to Operate Crane

Operators	1	each	1,920	hrs =	$	80,640	(Avg hrly labor cost is $42/hour)
Oilers	1	each	1,920	hrs =	$	80,640	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	2	each	3,840	hrs =	$	161,280	(Avg hrly labor cost is $32/hour)
Operating Cost (fuel, oil, grease)	1	each	1,920	hrs =	$	38,400	(assume $20/hour fuel, oil, and grease. Lessor pays for repairs)
Total Operations Cost =					*$*	*360,960*	

Equipment Rental Cost =	2,386,500	
Mobilization & De-mobilization =	928,000	(cost is for 2 mobs and demobs)
Operating Costs =	360,960	
Total Crane Costs =	3,675,460	

Appendix A

Cost Analysis, Leasing Option of Manitowoc 888 Crane Barge (3 Year Duration, 50% Usage)

Assumed duration of heavy lift crane	3	years	
Months out of each year crane operates	6.00	months per year	(minimum 6 month rental period)
Number of Mobilziations/De-mobs	3	each	
Cost of capital	8.0	percent	
Sales Tax Rate	7.5	percent	
No. of truck loads to move crane	60.0	each (there are 49 loads of just counterweight and ringer. Allow 10 more for crane and boom)	
No. of shifts to Mob or Demob crane	6.0	each	

Cost to Rent/Lease Crane			
Rental Cost of Crane and Ringer during operating period	$	1,980,000	(Manitowoc suggested $110,000/mo., minimum 6 mo rental applies)
Rental Cost of Barge during operation	$	1,350,000	(assume 240' x 80' x 15' barge is $3,000,000 new. Allow 2.5% per month lease.)
Rental Cost of Crane and Ringer during standby period	$	-	(allow 50% standby rent on idle equipment)
Rental Cost of Barge during standby	$	-	(allow 50% standby rent on idle equipment)
Sales Tax on rent	$	249,750	
Total leasing Cost =	*$*	*3,579,750*	

Cost to Mobilize and De-Mobilize Crane Once			
Cost to Transport Crane to Site	$	96,000	(16 hrs trucking per load x $100/hour trucking cost)
Cost to Transport Crane from Site	$	96,000	(16 hrs trucking per load x $100/hour trucking cost)
Cost to deliver barge to site	$	75,000	(say tug for 5 shifts at $10,000 per shift, plus $25,000 general expenses)
Cost to deliver barge from site	$	75,000	(say tug for 5 shifts at $10,000 per shift, plus $25,000 general expenses)
Cost to assemble Crane on site	$	36,000	(assume $6,000/shift to assemble crane - includes cost of 4100 helper crane)
Cost to dis-assemble Crane on site	$	36,000	(assume $6,000/shift to assemble crane - includes cost of 4100 helper crane)
Access trestle (100' x 50' @ $20/sf) to assmbl crane	$	100,000	
Mobilization/Demob Cost =	*$*	*514,000*	

Cost to Operate Crane							
Operators	1	each	2,880	hrs =	$	120,960	(Avg hrly labor cost is $42/hour)
Oilers	1	each	2,880	hrs =	$	120,960	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	2	each	5,760	hrs =	$	241,920	(Avg hrly labor cost is $32/hour)
Operating Cost (fuel, oil, grease)	1	each	2,880	hrs =	$	57,600	(assume $20/hour fuel, oil, and grease. Lessor pays for repairs)
Total Operations Cost =					*$*	*541,440*	

Equipment Rental Cost =	3,579,750	
Mobilization & De-mobilization =	1,342,000	(cost is for 3 mobs and demobs)
Operating Costs =	541,440	
Total Crane Costs =	5,463,190	

MANITOWOC M1200 *RINGER®*
ATTACHMENT

Shipping Weights and Dimensions

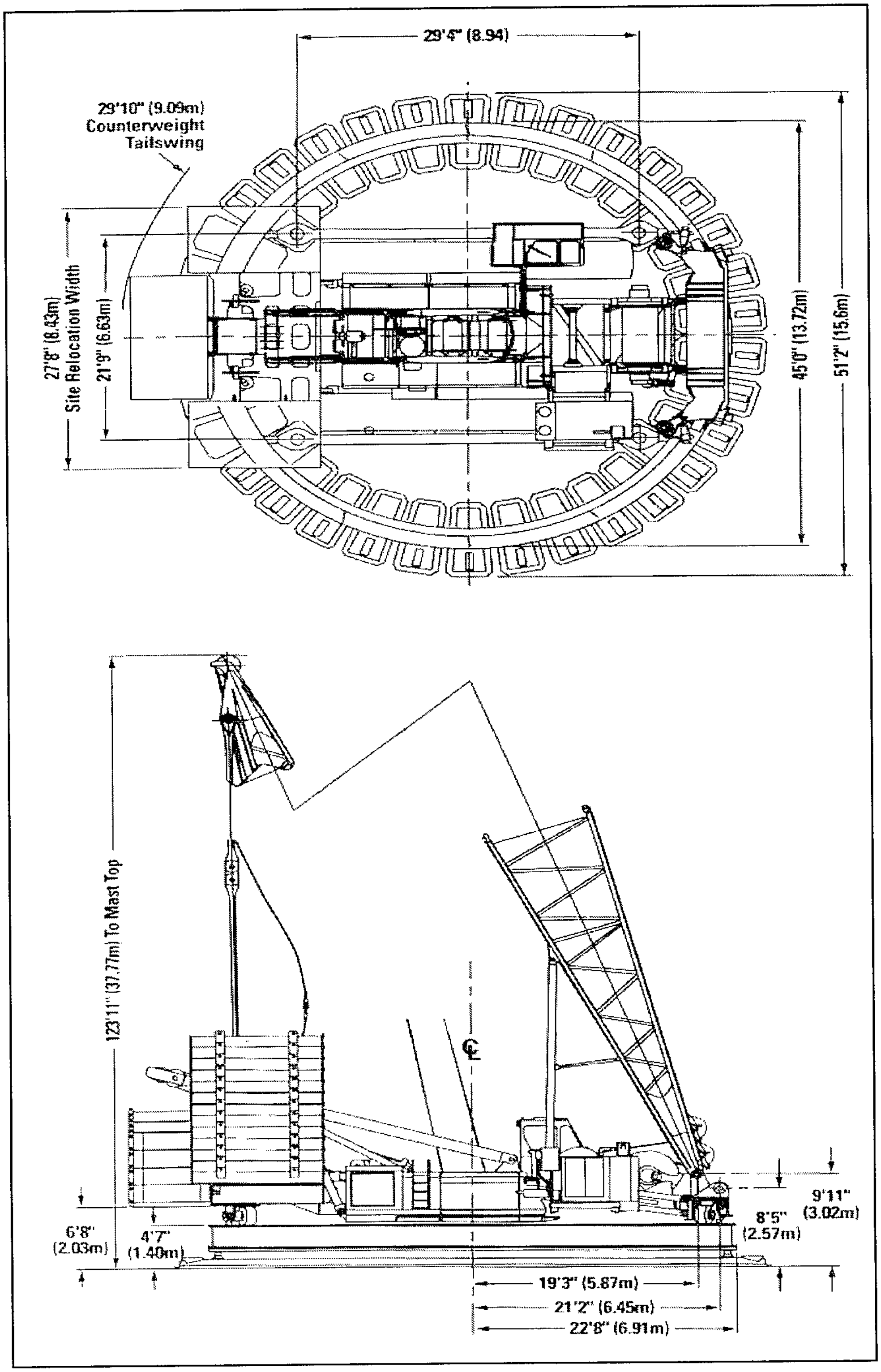
Component	Weight		Length		Width		Height	
	lb	kg	ft	m	ft	m	ft	m
Side beams (2), each	18,475	8,380	48'5"	14.76	3'0"	0.91	4'3"	1.30
Ring front segment	19,400	8,800	28'0"	8.53	6'6"	1.98	4'7"	1.40
Ring rear segment	19,400	8,800	28'0"	8.53	6'6"	1.98	4'7"	1.40
Ring side segments (2), each	27,250	12,360	42'0"	12.80	12'0"	3.65	4'7"	1.40
Ring support pedestals (34), each	2,040	925	7'11"	2.41	3'10"	1.17	2'2"	0.66
Front roller carrier	29,260	13,435	34'0"	10.36	8'6"	2.59	9'10"	3.00
Front (main) hoist and frame	29,540	13,400	12'0"	3.66	11'4"	3.45	8'6"	2.59
Main hoist wire rope 5,600' of 1¼" (1,707m of 32mm)	17,530	7,952	6'6"	1.98	6'6"	1.98	4'6"	1.37
Rear (auxiliary) hoist with rope	12,000	5,443	7'0"	2.13	5'6"	1.68	5'6"	1.68
Auxiliary power plant	10,775	4,887	11'4"	3.45	6'0"	1.83	8'0"	2.44
Counterweight carrier	57,650	26,150	43'2"	13.16	11'6"	3.51	8'10"	2.69
Counterweight center box (2), each	36,000	16,329	13'0"	3.96	7'11"	2.41	1'8"	0.51
Counterweight side box (26), each	44,000	19,958	11'6"	3.51	7'3"	2.21	1'9"	0.54
49A mast butt	14,610	6,627	40'6"	12.34	9'10"	3.00	10'2"	3.10
49A mast top	17,600	7,983	43'0"	13.11	9'10"	3.00	10'6"	3.20
49A mast insert	11,190	5,076	40'6"	12.34	9'10"	3.00	10'4"	3.15
67B boom butt	32,200	14,606	51'0"	15.54	11'0"	3.35	11'6"	3.51
67B boom top	33,600	15,241	54'4"	16.57	11'1"	3.38	11'3"	3.43
67B boom insert (25') (7.62m)	10,400	4,717	26'0"	7.92	11'0"	3.35	11'6"	3.51
67B boom insert (50') (15.24m)	21,650	9,821	51'0"	15.54	11'0"	3.35	11'6"	3.51
Upper boom point	1,475	669	11'6"	3.51	3'0"	0.91	3'6"	1.07

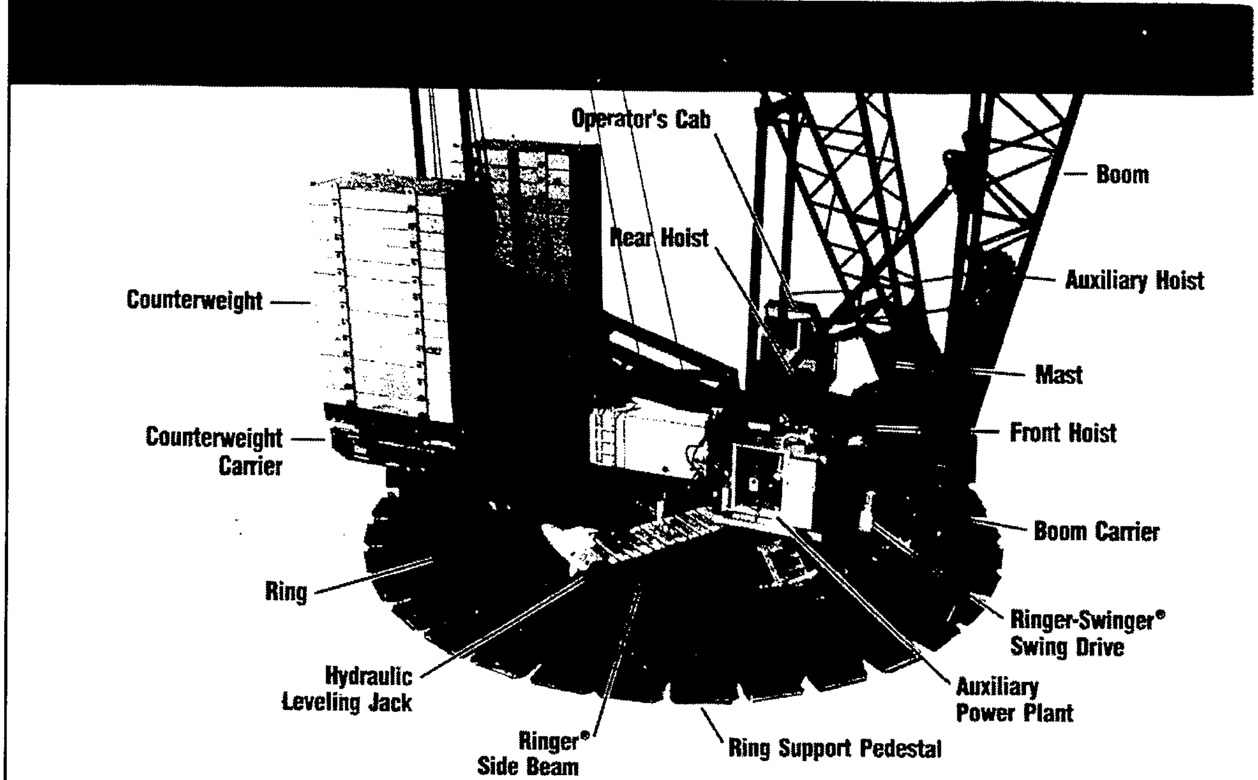
888 RINGER® Hoist Data

Application	Location	Drum Width	Lagging Diameter	Spooling Capacity	Single-Line Pull	Maximum Line Speed
Hoist Line	Front of Boom Carrier	70¼" (178.4cm)	35¾" (90.8cm)	4,859' (1,481m) of 1¼" (32mm) rope 7,062' (2,152m) of 1⅛" (28.6mm) rope	40,000 lb. (178 kN)	470 fpm (143 mpm) 8th layer
Whip Line	Rear of Boom Carrier	55" (139.7cm)	30½" (77.5cm)	3,714' (1,132m) of 1⅛" (28.6mm) rope	32,300 lb (144 kN)	429 fpm (131 mpm) 8th layer
Auxiliary Line	In Boom Butt	37" (94.0cm)	21¼" (54.0cm)	1,428' (435m) of 1" (25.4mm) rope	20,000 lb. (89.0 kN)	550 fpm (168 mpm) 6th layer

Swing Speed: 0.7 rpm **Travel Speed:** 1.0 mph (1.6 kph) **Boom Hoist Speed:** 425' (129.5 m) boom, 0°-82° – 12 minutes

MANITOWOC M1200 *RINGER®*
ATTACHMENT





Ringer® Side Beams: High-strength beams connect ring to basic crane. FACT™ connectors simplify set-up. Beams provide mounting for four hydraulic jacks that level the ring during set-up.

Ring: Four-section ring with FACT™ connectors is easy to transport and assemble. Ring's 45' (13.7m) diameter provides stability, yet fits into tight areas and requires minimal site preparation. Ring distributes loadings to the support pedestals. Side sections can be removed and installed quickly to reduce width for on-site travel.

Ring Support Pedestals: Thirty-four pedestals, each covering 3,000 in.² (1.9m²), distribute loadings to minimize ground-bearing pressure. Each pedestal's elevation can be adjusted to compensate for uneven surfaces.

Boom Carrier: Wide, high-strength weldment supports boom, mast, two swing drives, main hoist, power plant, and optional auxiliary hoist. Carrier's width and equalized rollers distribute loadings over large area of ring to provide stability and minimize ground-bearing pressure. FACT™ connectors permit fast installation.

Mast: Self-erecting 120' (36.6m) stationary mast is raised into place by the 888's boom hoist and is connected to the counterweight carrier by steel backhitch straps. Mast height permits raising of boom-and-jib combinations more than 600' (182.9m) long. Stationary design provides superior boom control.

Boom: 661.4-ton (600-metric-ton) capacity. Lengths from 125' (38.1m) to 425' (129.5m). Boom top accepts upper point, fixed jib, and luffing jib. Boom-support and backhitch straps stow atop corresponding sections of boom and mast.

Swing Drive: Four RINGER-SWINGER® hydraulic drives provide smooth, controlled swing to left or right, with free float when control lever is in neutral. Mounted to boom carrier and counterweight carrier, RINGER-SWINGERs® engage gear segments mounted to ring. System provides optimum distribution of torque and maximum control.

Auxiliary Power Plant: 330 hp (246 kW) diesel engine mounted to boom carrier works with basic crane's 330 hp, (246 kW) engine to power all functions. Efficient closed-loop hydraulics deliver maximum power and permit independent operation of each function.

Front Hoist: Hydraulically powered drum mounted on boom carrier raises and lowers main load block.. Spooling capacity permits full-range block travel with maximum loads. Redundant drives can *each* provide maximum required drum torque. Grooved laggings promote proper spooling and maximize rope life.

Rear Hoist: Optional hoist mounted behind main hoist on boom carrier is used for whipline on boom or as positioning hoist for luffing jib. Grooved laggings promote proper spooling and maximize rope life.

Auxiliary Hoist: Optional hoist mounted in boom butt provides high-speed hoisting of light loads and fast rigging of large loads. Grooved laggings promote proper spooling and maximize rope life. Also used as load hoist for luffing jib.

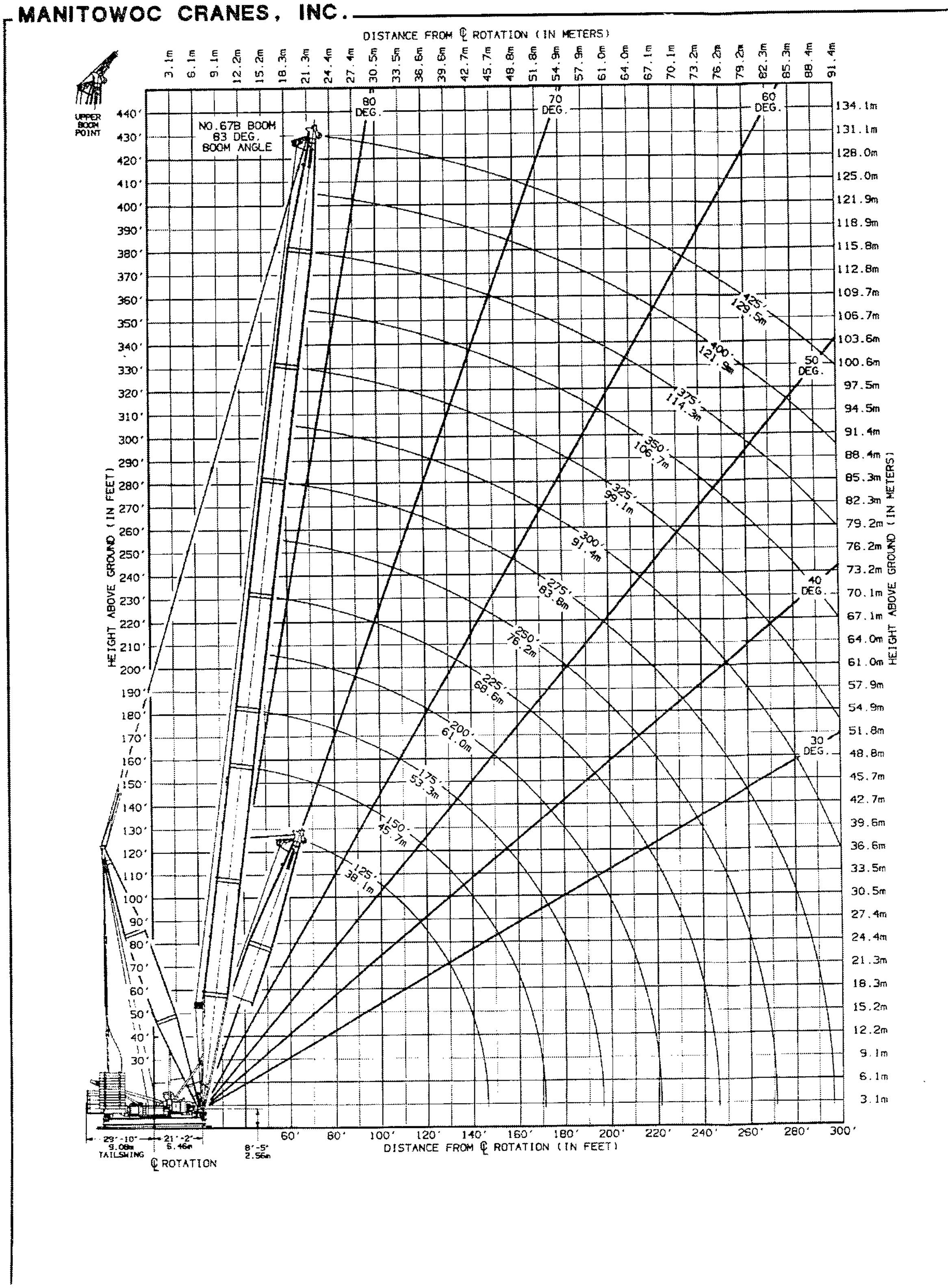
All hoists are equipped with ratchet-and-pawl motion locks.

Counterweight Carrier: High-strength platform supports counterweight and provides mounting for two swing drives. FACT™ connectors simplify installation. Carrier's width and equalized rollers distribute loadings over a large area of the ring.

Counterweight: Solid steel boxes stack and interlock on counterweight carrier. Boxes are sized and weighted for easy shipment.

Operator's Cab: Operator's cab from 888 crane is mounted on a pedestal to position operator for visibility. Control functions are changed from liftcrane to RINGER® mode electronically in the EPIC® microprocessor, eliminating repiping. EPIC® system provides precise control and monitors all functions.

Options:
Counterweight removal system
Detachable upper boom point
Stationary jib
Luffing jib
Load-moment indicator
Load blocks



8 RINGER RANGE DIAGRAM (#67B BOOM & #22EL FIXED JIB)

PRELIMINARY CAPACITY CHART

LIFTCRANE BOOM CAPACITIES
BOOM NO. 67B
1,395,100-LB AUXILIARY COUNTERWEIGHT
BARGE MOUNT - 1 DEGREE MACHINE LIST
NO TRAVEL - 360 DEGREE RATING

MANITOWOC
Model 888 RINGER
Boom No. 67B

Liftcrane capacities are for a machine when operating on a barge and do not exceed 75% of static tipping load. Capacities based on structural competence denoted by an asterisk (*).

Weight of all load blocks, hooks, weight balls, slings, hoist lines, etc., beneath boom point sheaves is considered part of load. Where no capacity is shown operation is not intended or approved.

Ringer equipped with 45' diameter ring, 120 No. 49A mast, 16-part boom hoist line, four 1-3/4" boom pendants and 1,395,100-lb auxiliary counterweight assembly. 888 equipped with 28' 2" long crawlers, 48" treads, 10' 3" gantry, 30' mast, 20-part mast reeving, four 1-3/8" mast self-erecting pendants, 0-lb crane and 0-lb carbody counterweight assemblies.

Radius (Feet)	Liftcrane Capacities (Thousands of Pounds) Boom Lengths (Feet)								
	125	150	175	200	225	250	275	300	325
45	1037.9*	999.4*							
50	972.6*	937.5*	878.1*						
55	914.8*	882.7*	852.2*	752.4*					
60	863.4*	833.8*	805.6*	743.9*	640.3*	554.9*			
65	817.5*	789.9*	763.6*	735.5*	633.6*	549.6*	483.2*		
70	776.0*	750.3*	725.7*	701.7*	626.9*	544.2*	478.9*	400.0*	327.1*
75	738.6*	714.4*	691.2*	668.6*	620.2*	538.9*	474.5*	400.0*	327.1*
80	704.5*	681.6*	659.7*	638.4*	613.7*	533.6*	470.1*	400.0*	327.1*
85	673.4*	651.6*	630.8*	610.6*	591.7*	528.2*	465.7*	400.0*	327.1*
90	644.9*	624.1*	604.3*	585.0*	567.1*	523.0*	461.3*	400.0*	327.1*
95	618.7*	598.8*	579.8*	561.4*	544.2*	517.7*	456.9*	400.0*	327.1*
100	573.6*	575.1	557.1*	539.5*	523.0*	506.5*	452.6*	397.1*	327.1*
110	488.1*	508.7	502.9	496.8	484.9*	469.6*	443.9*	389.9*	327.1*
120	415.9*	455.3	449.8	444.2	439.2	433.8	417.4*	382.6*	327.1*
130	351.4*	411.4	406.2	400.9	396.2	391.1	384.1*	359.1*	327.1*
140	286.7*	361.8*	369.6	364.6	360.1	355.3	351.1	332.8*	311.5*
150		314.2*	338.5	333.8	329.4	324.8	320.8	309.7*	290.3*
160		267.4*	311.8	307.2	303.0	298.5	294.7	289.0*	271.4*
170			277.4*	284.1	280.0	275.6	271.9	267.5	254.4*
180			242.5*	263.8	259.8	255.5	251.9	247.6	238.9*
190			204.1*	243.6*	241.9	237.7	234.2	230.0	224.7*
200				217.0*	226.0	221.8	218.3	214.2	210.6
210				188.9*	211.7	207.6	204.1	200.1	196.5
220					192.5*	194.7	191.3	187.3	183.8
230					171.0*	183.0	179.7	175.7	172.3
240						169.1*	169.1	165.1	161.7
250						152.2*	159.4	155.5	152.1
260						133.7*	148.3*	146.6	143.2
270							134.8*	138.4	135.1
280							120.3*	128.3*	127.5
290								117.3*	119.6*
300								105.6*	110.6*
310								92.5*	101.5*
320									91.9*
330									81.5*
335									75.5*

MANITOWOC ENGINEERING CO.
Division of The Manitowoc Company, Inc.
P.O. Box 70 ♦ Manitowoc, WI 54221-0070
Telephone: 414-684-6621 ♦ Fax: 414-683-6277

NOTICE: This capacity chart is for reference use only and must not be used for lifting purposes. Regular capacity charts for a specific crane can be purchased from an authorized Manitowoc Distributor.

PRELIMINARY CAPACITY CHART

LIFTCRANE BOOM CAPACITIES
BOOM NO. 67B
1,395,100-LB AUXILIARY COUNTERWEIGHT
BARGE MOUNT - 2 DEGREE MACHINE LIST
NO TRAVEL - 360 DEGREE RATING

MANITOWOC

Model 888 RINGER
Boom No. 67B

Liftcrane capacities are for a machine when operating on a barge and do not exceed 75% of static tipping load. Capacities based on structural competence denoted by an asterisk (*).

Weight of all load blocks, hooks, weight balls, slings, hoist lines, etc., beneath boom point sheaves is considered part of load. Where no capacity is shown operation is not intended or approved.

Ringer equipped with 45' diameter ring, 120 No. 49A mast, 16-part boom hoist line, four 1-3/4" boom pendants and 1,395,100-lb auxiliary counterweight assembly 888 equipped with 28' 2" long crawlers, 48" treads, 10' 3" gantry, 30' mast, 20-part mast reeving, four 1-3/8" mast self-erecting pendants, 0-lb crane and 0-lb carbody counterweight assemblies.

Liftcrane Capacities (Thousands of Pounds)								
Radius	Boom Lengths (Feet)							
(Feet)	125	150	175	200	225	250	275	300
45	903.4*							
50	853.5*	805.0*						
55	808.9*	764.1*	722.9*					
60	768.8*	727.1*	688.7*	607.9*	518.9*			
65	732.6*	693.6*	657.6*	602.0*	514.0*	442.6*		
70	699.7*	663.1*	629.2*	596.0*	509.2*	438.7*	366.4*	
75	669.7*	635.1*	603.1*	573.1*	504.4*	434.8*	366.4*	293.7*
80	642.4*	609.4*	579.0*	550.6*	499.7*	430.9*	366.4*	293.7*
85	602.6*	585.8*	556.8*	529.7*	495.0*	427.1*	366.4*	293.7*
90	567.2*	564.0*	536.2*	510.3*	486.6*	423.2*	366.4*	293.7*
95	535.6*	532.6*	517.0*	492.2*	469.5*	419.4*	366.4*	293.7*
100	507.1*	504.2*	499.2*	475.4*	453.5*	415.5*	363.7*	293.7*
110	457.8*	455.0*	452.0*	444.8*	424.5*	404.7*	357.3*	293.7*
120	409.9*	414.0*	411.0*	407.9*	398.7*	380.2*	350.9*	293.7*
130	347.6*	379.3*	376.3*	373.3*	370.5*	358.3*	342.6*	293.7*
140	284.8*	349.5*	346.6*	343.6*	340.8*	337.6*	323.7*	293.7*
150		310.5*	320.8*	317.8*	315.0*	311.1	305.8	290.0*
160		265.2*	298.1*	295.3*	292.3	286.7	281.7	276.1
170			273.9*	275.3*	270.8	265.3	260.6	255.2
180			240.1*	257.0	251.8	246.5	241.9	236.8
190			202.9*	240.1	235.0	229.8	225.4	220.4
200				214.6*	219.9	214.8	210.5	205.7
210				187.4*	206.5	201.4	197.2	192.4
220					190.1*	189.3	185.1	180.4
230					169.4*	178.3	174.2	169.5
240						166.8*	164.2	159.6
250						150.5*	155.0	150.5
260						132.6*	146.1*	142.1
270							133.1*	134.4
280							119.1*	126.2*
290								115.6*
300								104.4*
310								91.6*

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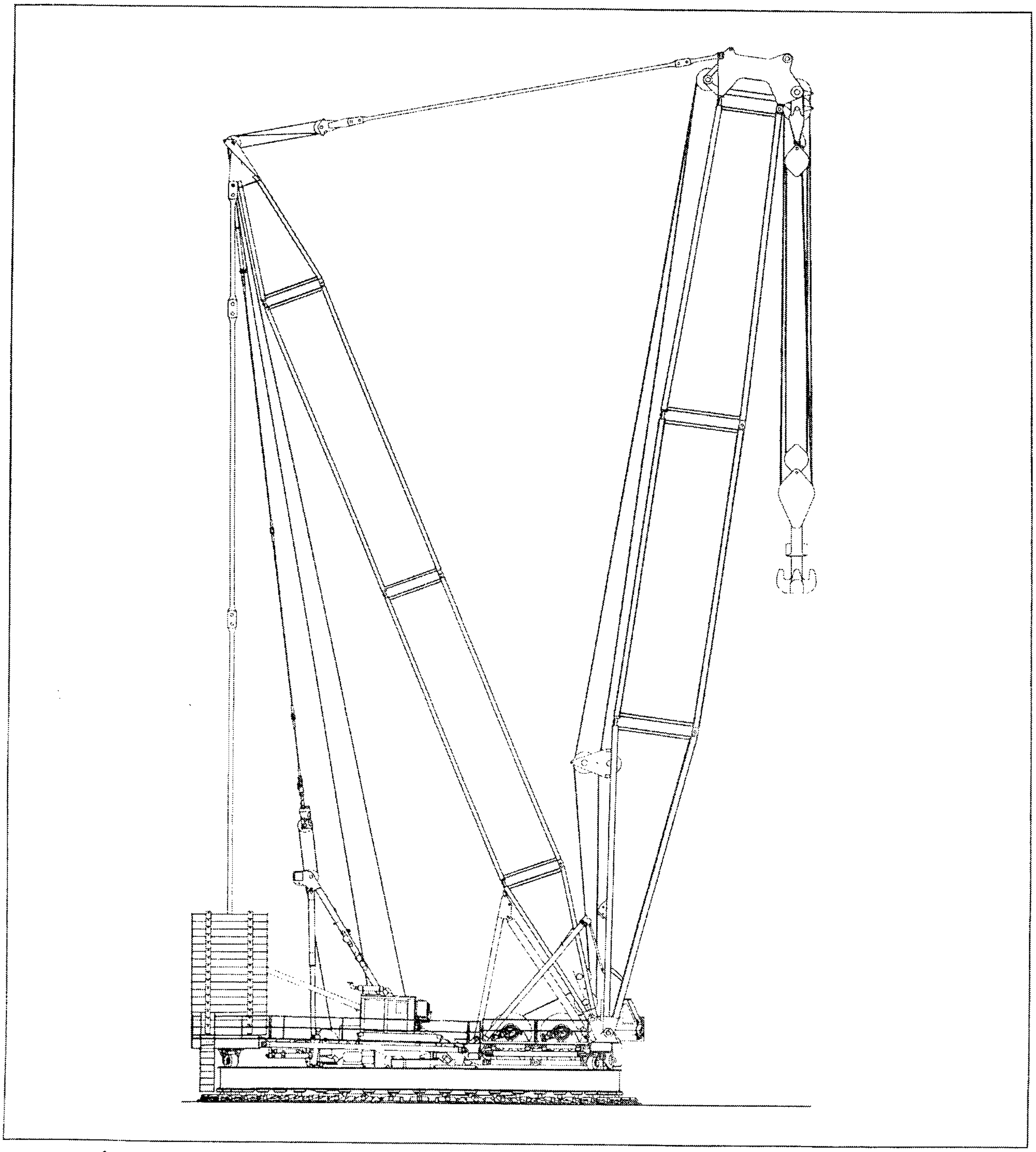
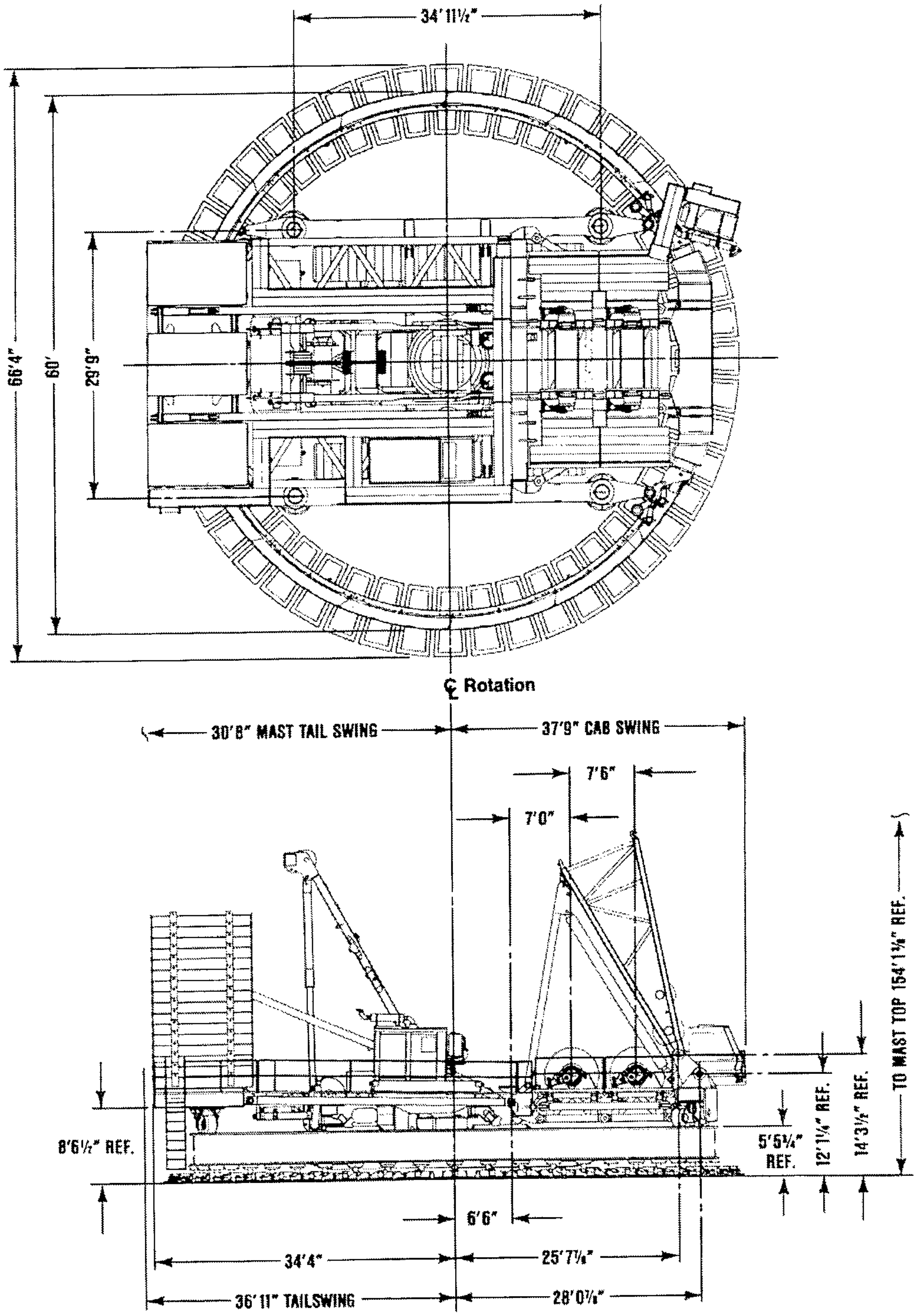
MANITOWOC M1200 *RINGER®*
ATTACHMENT



Main-Boom Capacities to 1,433 tons ▪ Jib Capacities to 882 tons

M-1200 RINGER OUTLINE DIMENSIONS



M-250 CRANE EQUIPMENT FOR USE WITH RINGER ATTACHMENT

DRUMS: Full-width front and rear drums, each 66" wide, 22½" in diameter, and equipped with ratchet and pawl. Each drum accepts a spacer that allows use in standard liftcrane work when the crane is not in the RINGER attachment.

SWING: Two swing drives.

CARBODY: Carbody equipped with a support bracket at each corner for mounting the RINGER side frames.

M-1200 RINGER BASIC COMPONENTS

(for all configurations)

RING: 60' diameter ring supports the counterweight carrier and boom carrier. Ring formed by four structural-steel segments equipped with FACT connectors for rapid assembly. Each segment provides mounting for 12 support pedestals and a section of the swing gear. Wear plates on top of ring provide smooth, renewable rolling surface.

SUPPORT PEDESTALS: 48 structural-steel pedestals FACT-connected to bottom of ring provide support and distribute loads from ring to ground. Each pedestal is equipped with a manual screw-style adjustor for fast, easy leveling of the ring.

RINGER SIDE FRAMES: Structural-steel beams pin-connected to the M-250's crawler frames and carbody provide support for the ring. FACT connectors automatically align the powered pins that secure the RINGER side frames to the M-250. Four hydraulic jacks housed in the RINGER side frames elevate and level the ring during set-up.

TRANSVERSE ADAPTER BEAM: High-strength structural-steel beam is FACT connected to the RINGER's rear hoist frame, the M-250's rotating module, and the RINGER's shear frames. Torque loadings from RINGER boom carrier are transferred through hoist frames to the transverse beam, which distributes them through the shear frames to the RINGER's counterweight carrier.

HOIST MODULES: Two lattice-type steel weldments support the RINGER's hoist drums. The rear hoist module pin-connects to the transverse beam and the front hoist module. The front hoist module pin-connects to the RINGER's boom carrier. Both structures are required regardless of whether one or two hoisting drums are used. All connections between boom carrier, hoist modules, transverse beam, and shear frames feature FACT for fast set-up and takedown.

BOOM CARRIER: Structural-steel weldment pin-connected to the front hoist module. Boom carrier contains connections for RINGER boom and mast, and transfers boom loadings to the ring and support pedestals through equalized rollers.

SWING SYSTEM: Manitowoc's patented RINGER-SWINGERs, mounted to each side of the boom carrier, combine with the M-250 crane's swing system to provide smooth, hydraulically powered swing in either direction. Free float exists when the swing system is in neutral.

COUNTERWEIGHT CARRIER: Structural-steel platform, located behind basic crane, supports RINGER counterweights and distributes counterweight load to the ring through equalized rollers. Counterweight carrier is connected to the boom carrier by structural-steel shear frames, the transverse beam, and the hoist modules.

M-1200 RINGER CONFIGURATIONS

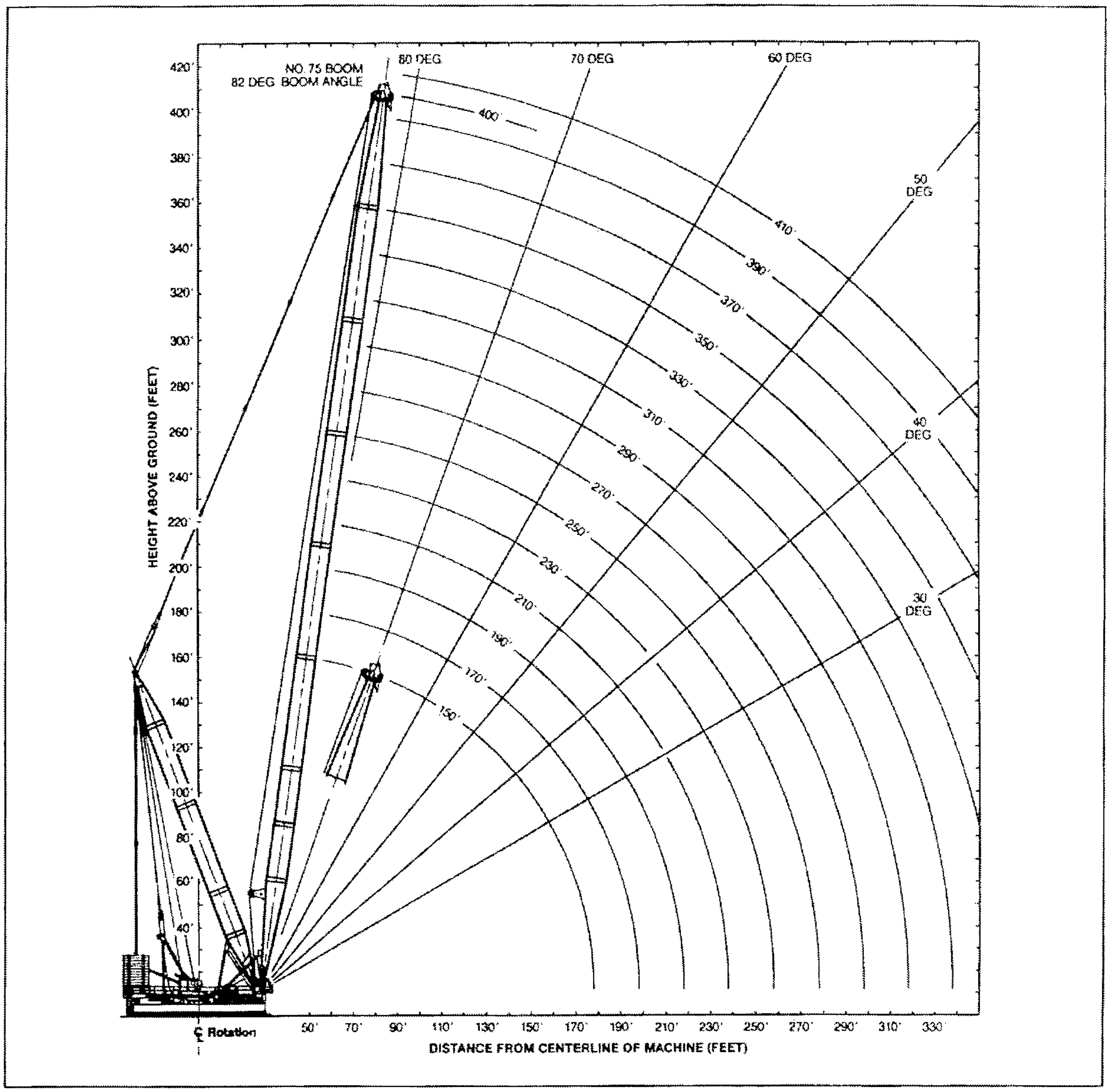
Maximum Capacity	827 U.S. tons	1,433 U.S. tons	882 U.S. tons
Configuration	Single Engine One Hoist Drum	Dual Engines Two Hoist Drums	Dual Engines Two Hoist Drums
Boom Number	75	72	75 Jib on 72 Boom
Basic Length	150'	153'	100'
Maximum Length	400'	403'	250'
Automatic Boom Stop	Yes	Yes	Yes
Air-Cushioned Boom Stop	Yes	Yes	Yes
Mast Number	49A/75	75	75
Mast Length	150'	150'	150'
Number of RINGER-SWINGERs	2	4	4
Boom Hoist	One or two full-width hoist drums of M-250 crane	Two full-width hoist drums of M-250 crane	Two full-width hoist drums of M-250 crane
Load Hoist	One or two full-width drums mounted to RINGER attachment	Two full-width drums mounted to RINGER attachment	Two full-width drums mounted to RINGER attachment

SYSTEM FUNCTIONS

Component or System	Configuration	
	One RINGER Hoist Drum	Two RINGER Hoist Drums
M-250's Front Drum	Boom Hoist	Boom Hoist
M-250's Rear Drum	Boom Hoist (Optional)	Boom Hoist
M-250's Boom Hoist	Mast Hoist	Mast Hoist
Front Hoist Module	Load Hoist	Load Hoist
Rear Hoist Module	Not Present	Load Hoist
M-250's Swing System and RINGER Attachment's RINGER-SWINGERs	Swing	Swing
M-250's Travel System	Travel	Travel
M-250's Diesel Engine (450 HP)	Powers Swing, Load Hoist, Travel, and Boom Hoist	Powers half of Swing and Load Hoist, all of Boom Hoist and Travel
RINGER Attachment's Auxiliary Diesel Engine (450 HP)	Optional. If selected, complements power for Load Hoist and Swing	Complements power for Load Hoist and Swing

M-1200R

827-TON CONFIGURATION



NO. 75 BOOM: 150' basic length consists of 50' butt, 50' insert, and 50' top with boom-point sheave carrier. Boom top is connected to equalizer by solid-steel pendant straps. Boom length can be increased to a maximum of 400' with 25' and 50' inserts, and pendant straps. All boom sections feature FACT connectors for easy assembly. Automatic boom stop and air-cushioned boom stop included. Jibs will be optional.

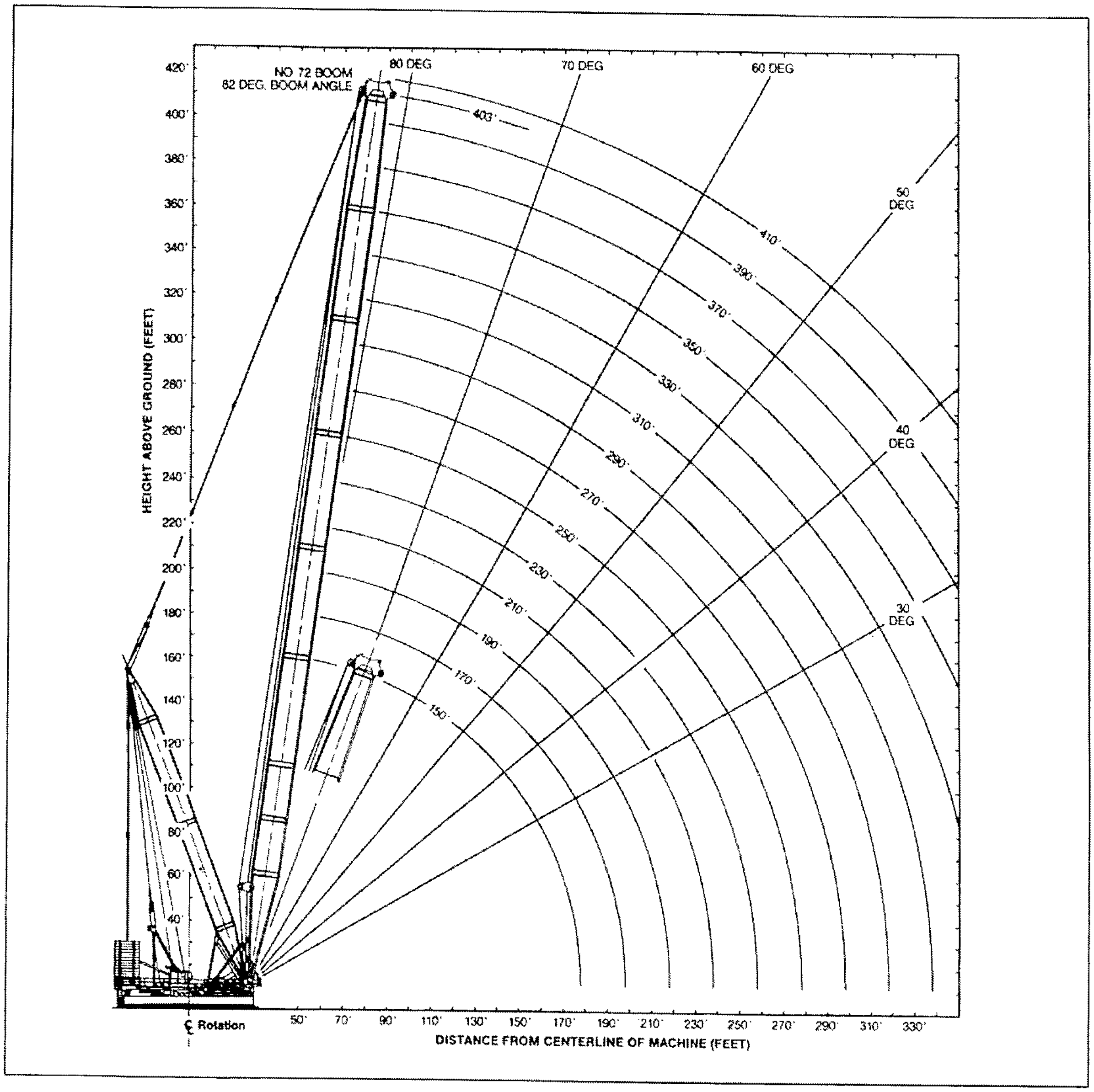
NO. 49A/75 MAST: 150' mast consists of 25' butt, one 20' insert, two 40' inserts, and 25' top. Mast top is connected to RINGER counterweight tray by steel pendant straps. Structural-steel frame mounted to butt supports mast. Mast provides mounting for wire rope guides for the RINGER's front and rear hoist drums.

SWING SYSTEM: Two RINGER-SWINGERs, one mounted at each side of the boom carrier, work with the M-250 crane's swing system to provide hydraulically powered swing.

BOOM HOIST: One of the M-250 crane's full-width drums provides boom-hoist function. Line reeved from drum through sheaves in mast top and equalizer forms multi-part boom-hoist rigging. Equalizer is connected to boom top by pendant straps. Use of both M-250 full-width drums for boom hoist is optional in this RINGER configuration.

LOAD HOIST: Single full-width auxiliary drum mounted on front hoist module is standard. The drum is equipped with a two-speed hydraulic motor and planetary gear reduction at each end, and is powered by the M-250. Use of two full-width auxiliary drums for load hoist is optional in this RINGER configuration.

1,433-TON CONFIGURATION



NO. 72 BOOM: 153' basic length consists of 50' butt, 50' standard insert, 50' transition insert, and 3' top with boom-point sheave carrier. Boom top is connected to equalizer by solid-steel pendant straps. Boom length can be increased to a maximum of 403' with 25' and 50' inserts, and pendant straps. All boom sections feature FACT connectors for easy assembly. Automatic boom stop and air-cushioned boom stop included. Boom sections measure 18'10" wide by 12'10" high. To simplify shipment, boom sections divide longitudinally and interlock, reducing overall width to 10'.

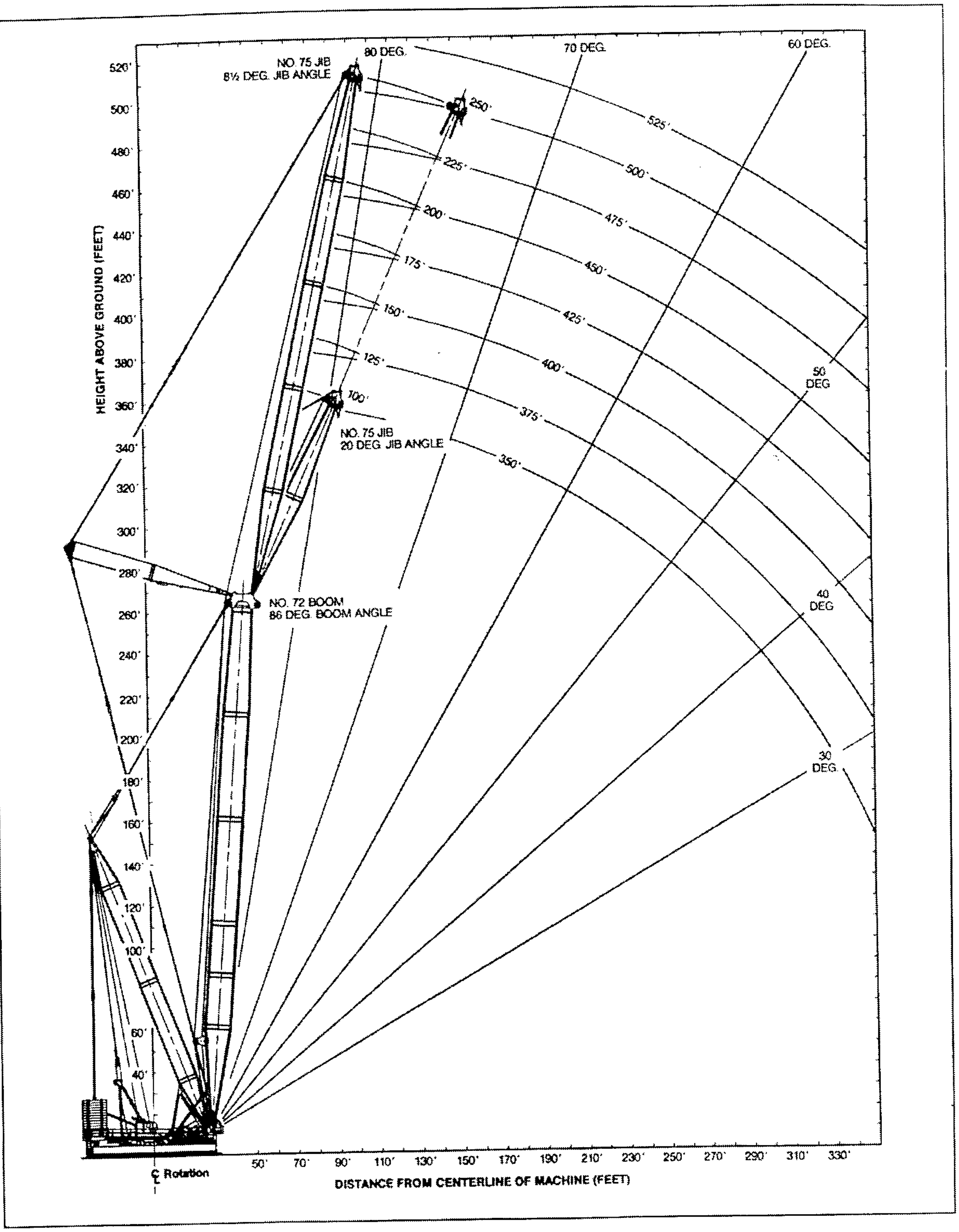
NO. 75 MAST: 150' mast consists of 25' butt, two 50' inserts, and 25' top. Mast top is connected to RINGER counterweight tray by steel pendant straps. Structural-steel frame mounted to butt supports mast. Mast provides mounting for wire rope guides for RINGER's front and rear hoist drums.

SWING SYSTEM: Four RINGER-SWINGERs, two mounted at each side of the boom carrier, work with the M-250 crane's swing system to provide hydraulically powered swing.

BOOM HOIST: Both of the M-250 crane's full-width drums provide boom-hoist function. Line reeved from drums through sheaves in mast top and equalizer forms multi-part boom-hoist rigging. Equalizer connected to boom top by pendant straps.

LOAD HOIST: Two full-width auxiliary drums mounted on RINGER's hoist modules are standard. Each drum is equipped with a two-speed hydraulic motor and planetary gear reduction at each end. Drums are powered by M-250 and supplemental Cummins NTA-855, 450-HP diesel engine.

882-TON NO. 75 JIB FOR USE ON NO. 72 BOOM



NO. 75 JIB: 100' basic length consists of 50' butt and 50' top with lower-boom-point sheave carrier. Length can be increased to a maximum of 250' with 25' and 50' inserts, and pendant straps. Jib strut consists of cap, solid-steel backstay, and pendant straps. Strut uses 40' No. 44 butt and 40' No. 44 insert from the M-250 liftcrane.

MANITOWOC M1200 *RINGER®*
ATTACHMENT

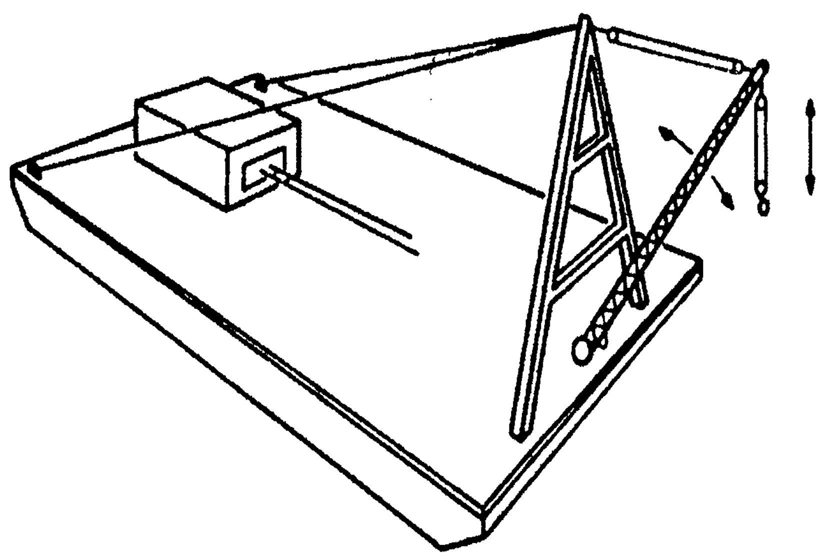
PERFORMANCE DATA						
	Configuration					
	One Hoist Drum			Two Hoist Drums		
Drum(s)						
Location	Front Hoist Module			Front and Rear Hoist Modules		
Diameter	32.5"			32.5" each		
Width	77.62"			77.62" each		
Layers	11			11 each		
Operational Spooling Capacity[1]	6,330'			6,330' each		
Wire Rope[2]						
Diameter	1⅝"			1⅝"		
Type	Extra Improved Plow Steel (EIPS), IWRC, Regular Lay			Extra Improved Plow Steel (EIPS), IWRC, Regular Lay		
Breaking Strength	264,000 lbs			264,000 lbs		
Weight/Foot	4.88 lbs			4.88 lbs		
Rated Single-Line Pull and Speed[3]	**Lo**	**Hi**		**Lo**	**Hi**	
0 lbs	150	275	fpm	150	275	fpm each
10,000 lbs	147	265	fpm	147	265	fpm each
20,000 lbs	145	257	fpm	145	257	fpm each
30,000 lbs	142	250	fpm	142	250	fpm each
40,000 lbs	140	N/A	fpm	140	N/A	fpm each
50,000 lbs	137	N/A	fpm	137	N/A	fpm each
60,000 lbs	135	N/A	fpm	135	N/A	fpm each

[1]Based on 1⅝" diameter wire rope.
[2]Standard wire rope. Consult factory for options.
[3]Rated line pull of each drum is infinitely variable from 0 to 60,000 lbs.

SWING SPEED: Infinitely variable. 0.70 rpm maximum, depending upon swing arrangement selected.

BOOM HOIST SPEED:
400' No. 75 boom, 0 to 82° — 10 minutes, 0 seconds.
403' No. 72 boom, 0 to 82° — 19 minutes, 0 seconds.

Appendix B Technical Data and Cost Estimates on A-frame Shear-Leg Crane Barges



A-Frame Derrick Crane

Appendix B

Economic Analysis of Purchasing 700 Ton "A-Frame" Derrick Barge

Assumed duration of heavy lift crane	1.0	years
Months out of each year crane operates	12	months per year
Cost of capital	8.0	percent
Sales Tax Rate	7.5	percent
Depreciation on Barge, Total	20.0	percent
Depreciation on Lift Frame, Total	40.0	percent

Cost to Purchase Crane Barge

Purchase 200' x 70' x 15' Derrick Barge, incl mooring =	$	3,500,000	(estimate suggested by Bisso Marine)
700 ton A Frame Lifting and mooring Equipment =	$	3,000,000	(estimate suggested by Bisso Marine)
Total Purchase Cost =	$	6,500,000	
Cost of Capital for duration of lift crane use	$	520,000	
Sales Tax on purchase	$	487,500	
Depreciation Cost on Barge	$	700,000	
Depreciation Cost on Lifting Frame	$	1,200,000	
Total Cost of Ownership =	*$*	*2,907,500*	

Cost to Mobilize and De-Mobilize Derrick Barge Once

Cost to deliver barge to site	$	72,500	(say tug for 7 shifts at $7,500 per shift, plus $20,000 general expenses)
Cost to deliver barge from site	$	72,500	(say tug for 7 shifts at $7,500 per shift, plus $20,000 general expenses)
Assemble and Dissassemble frames and rigging	$	62,500	(say 4 sh to assmb., 3 sh to dissassmb. $7,500 per shift, $10,000 general expenses)
Mobilization/Demob =	*$*	*207,500*	

Cost to Operate Crane

Operators	1	ea x	1,920	hrs =	$	80,640	(Avg hrly labor cost is $42/hour)
Oilers	2	ea x	3,840	hrs =	$	122,880	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	4	ea x	7,680	hrs =	$	245,760	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1	ea x	1,920	hrs =	$	157,440	(assume $20/hour fuel, oil, and grease plus $60/hour in parts and mechanic time)
Total Operating Cost =					*$*	*606,720*	

Equipment Rental Cost =	2,907,500	
Mobilization & De-mobilization =	207,500	(cost is for 1 mob and demob since the crane is purchased and remains on job)
Operating Costs =	606,720	
Total Crane Costs =	3,721,720	

Appendix B

Economic Analysis of Purchasing 700 Ton "A-Frame" Derrick Barge

Assumed duration of heavy lift crane	2.0	years
Months out of each year crane operates	6	months per year
Cost of capital	8.0	percent
Sales Tax Rate	7.5	percent
Depreciation on Barge, Total	20.0	percent
Depreciation on Lift Frame, Total	40.0	percent

Cost to Purchase Crane Barge			
Purchase 200' x 70' x 15' Derrick Barge, incl mooring =	$	3,500,000	(estimate suggested by Bisso Marine)
700 ton A Frame Lifting and mooring Equipment =	$	3,000,000	(estimate suggested by Bisso Marine)
Total Purchase Cost =	$	6,500,000	
Cost of Capital for duration of lift crane use	$	1,081,600	
Sales Tax on purchase	$	487,500	
Depreciation Cost on Barge	$	700,000	
Depreciation Cost on Lifting Frame	$	1,200,000	
Total Cost of Ownership =	*$*	*3,469,100*	

Cost to Mobilize and De-Mobilize Derrick Barge Once			
Cost to deliver barge to site	$	72,500	(say tug for 7 shifts at $7,500 per shift, plus $20,000 general expenses)
Cost to deliver barge from site	$	72,500	(say tug for 7 shifts at $7,500 per shift, plus $20,000 general expenses)
Assemble and Dissassemble frames and rigging	$	62,500	(say 4 sh to assmb., 3 sh to dissassmb. $7,500 per shift, $10,000 general expenses)
Mobilization/Demob =	*$*	*207,500*	

Cost to Operate Crane								
Operators	1	ea x	1,920	hrs =	$	80,640	(Avg hrly labor cost is $42/hour)
Oilers	2	ea x	3,840	hrs =	$	122,880	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	4	ea x	7,680	hrs =	$	245,760	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1	ea x	1,920	hrs =	$	157,440	(assume $20/hour fuel, oil, and grease plus $60/hour in parts and mechanic time)
Total Operating Cost =					*$*	*606,720*	

Equipment Rental Cost =	3,469,100	
Mobilization & De-mobilization =	207,500	(cost is for 1 mob and demob since the crane is purchased and remains on job)
Operating Costs =	606,720	
Total Crane Costs =	4,283,320	

Appendix B

Economic Analysis of Purchasing 700 Ton "A-Frame" Derrick Barge

Assumed duration of heavy lift crane	3.0	years
Months out of each year crane operates	6	months per year
Cost of capital	8.0	percent
Sales Tax Rate	7.5	percent
Depreciation on Barge, Total	20.0	percent
Depreciation on Lift Frame, Total	40.0	percent

Cost to Purchase Crane Barge

Purchase 200' x 70' x 15' Derrick Barge, incl mooring =	$	3,500,000	(estimate suggested by Bisso Marine)
700 ton A Frame Lifting and mooring Equipment =	$	3,000,000	(estimate suggested by Bisso Marine)
Total Purchase Cost =	$	6,500,000	
Cost of Capital for duration of lift crane use	$	1,688,128	
Sales Tax on purchase	$	487,500	
Depreciation Cost on Barge	$	700,000	
Depreciation Cost on Lifting Frame	$	1,200,000	
Total Cost of Ownership =	*$*	*4,075,628*	

Cost to Mobilize and De-Mobilize Derrick Barge Once

Cost to deliver barge to site	$	72,500	(say tug for 7 shifts at $7,500 per shift, plus $20,000 general expenses)
Cost to deliver barge from site	$	72,500	(say tug for 7 shifts at $7,500 per shift, plus $20,000 general expenses)
Assemble and Dissassemble frames and rigging	$	62,500	(say 4 sh to assmb., 3 sh to dissassmb. $7,500 per shift, $10,000 general expenses)
Mobilization/Demob =	*$*	*207,500*	

Cost to Operate Crane

Operators	1	ea x	2,880	hrs =	$	120,960	(Avg hrly labor cost is $42/hour)
Oilers	2	ea x	5,760	hrs =	$	184,320	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	4	ea x	#####	hrs =	$	368,640	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1	ea x	2,880	hrs =	$	236,160	(assume $20/hour fuel, oil, and grease plus $60/hour in parts and mechanic time)
Total Operating Cost =					*$*	*910,080*	

Equipment Rental Cost =	4,075,628	
Mobilization & De-mobilization =	207,500	(cost is for 1 mob and demob since the crane is purchased and remains on job)
Operating Costs =	910,080	
Total Crane Costs =	5,193,208	

Appendix B

Cost Analysis of leasing a 700 Ton "A-Frame" Crane Barge (1 years, 100% Usage)

Assumed duration of heavy lift crane	1	years	
Months out of each year crane operates	12.00	months per year, minimum rental period = 6 months	
Number of Mobilziations/De-mobs	1.0	each	
Sales Tax Rate	7.5	percent	*$15,000 per cal. day for 6 mo. rental*
Daily rental rate on derrick barge	12,500	per calendar day	*$12,500 per cal. day for 12 mo. rental*
			$10,000 per cal. day for 18 mo. rental

Cost to Rent/Lease Crane					
Lease 700 ton Derrick Barge	365 cal. Day @	$ 12,500	=	4,562,500	(rental rate suggesed by Bisso Marine with minimum rental)
Sales Tax on Lease				342,188	
Total Cost of Ownership =				*$ 4,904,688*	

Cost to Mobilize and Demobilize Crane Once		
Cost to deliver barge to site	65,000	(tug for 11 shifts at $5,000/shift, $10,000 general expenses)
Cost to deliver barge from site	65,000	(tug for 11 shifts at $5,000/shift, $10,000 general expenses)
Assemble and Dissassemble frames and rigging	65,000	(5 shifts to assmb., 4 shifts to dissassmb. $7,500 per shift)
Mobilization/Demob Cost =	*$ 195,000*	

Operating Cost				
Operators	1 ea x	1,920 hrs =	80,640	(Avg hrly labor cost is $42/hour)
Oilers	2 ea x	3,840 hrs =	122,880	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	4 ea x	7,680 hrs =	245,760	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, maint.	1 ea x	1,920 hrs =	38,400	(assume $20/hour fuel, oil. Lessor pays for maintenance)
Operating Cost =			*$ 407,040*	

Equipment Rental Cost =	4,904,688	
Mobilization & De-mobilization =	195,000	(cost is for 1 mob and demob)
Operating Costs =	487,680	
Total Crane Costs =	5,587,368	

Appendix B

Cost Analysis of leasing a 700 Ton "A-Frame" Crane Barge (2 years, 50% Usage)

Assumed duration of heavy lift crane	2	years	
Months out of each year crane operates	6.00	months per year, minimum rental period = 6 months	
Number of Mobilziations/De-mobs	2.0	each	
Sales Tax Rate	7.5	percent	*$15,000 per cal. day for 6 mo. rental*
Daily rental rate on derrick barge	15,000	per calendar day	*$12,500 per cal. day for 12 mo. rental*
			$10,000 per cal. day for 18 mo. rental

Cost to Rent/Lease Crane					
Lease 700 ton Derrick Barge	365 cal. Day @	$ 12,500	=	4,562,500	(rental rate suggesed by Bisso Marine with minimum rental)
Sales Tax on Lease				342,188	
Total Cost of Ownership =				*$ 4,904,688*	

Cost to Mobilize and Demobilize Crane Once		
Cost to deliver barge to site	65,000	(tug for 11 shifts at $5,000/shift, $10,000 general expenses)
Cost to deliver barge from site	65,000	(tug for 11 shifts at $5,000/shift, $10,000 general expenses)
Assemble and Dissassemble frames and rigging	65,000	(5 shifts to assmb., 4 shifts to dissassmb. $7,500 per shift)
Mobilization/Demob Cost =	*$ 195,000*	

Operating Cost					
Operators	1 ea x	1,920	hrs =	80,640	(Avg hrly labor cost is $42/hour)
Oilers	2 ea x	3,840	hrs =	122,880	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	4 ea x	7,680	hrs =	245,760	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, maint.	1 ea x	1,920	hrs =	38,400	(assume $20/hour fuel, oil. Lessor pays for maintenance)
Operating Cost =				*$ 407,040*	

Equipment Rental Cost =	4,904,688	
Mobilization & De-mobilization =	390,000	(cost is for 2 mob and demob)
Operating Costs =	487,680	
Total Crane Costs =	5,782,368	

Appendix B

Cost Analysis of leasing a 700 Ton "A-Frame" Crane Barge (3 years, 50% Usage)

Assumed duration of heavy lift crane	3	years
Months out of each year crane operates	6.00	months per year, minimum rental period = 6 months
Number of Mobilziations/De-mobs	3.0	each
Sales Tax Rate	7.5	percent
Daily rental rate on derrick barge	15,000	per calendar day

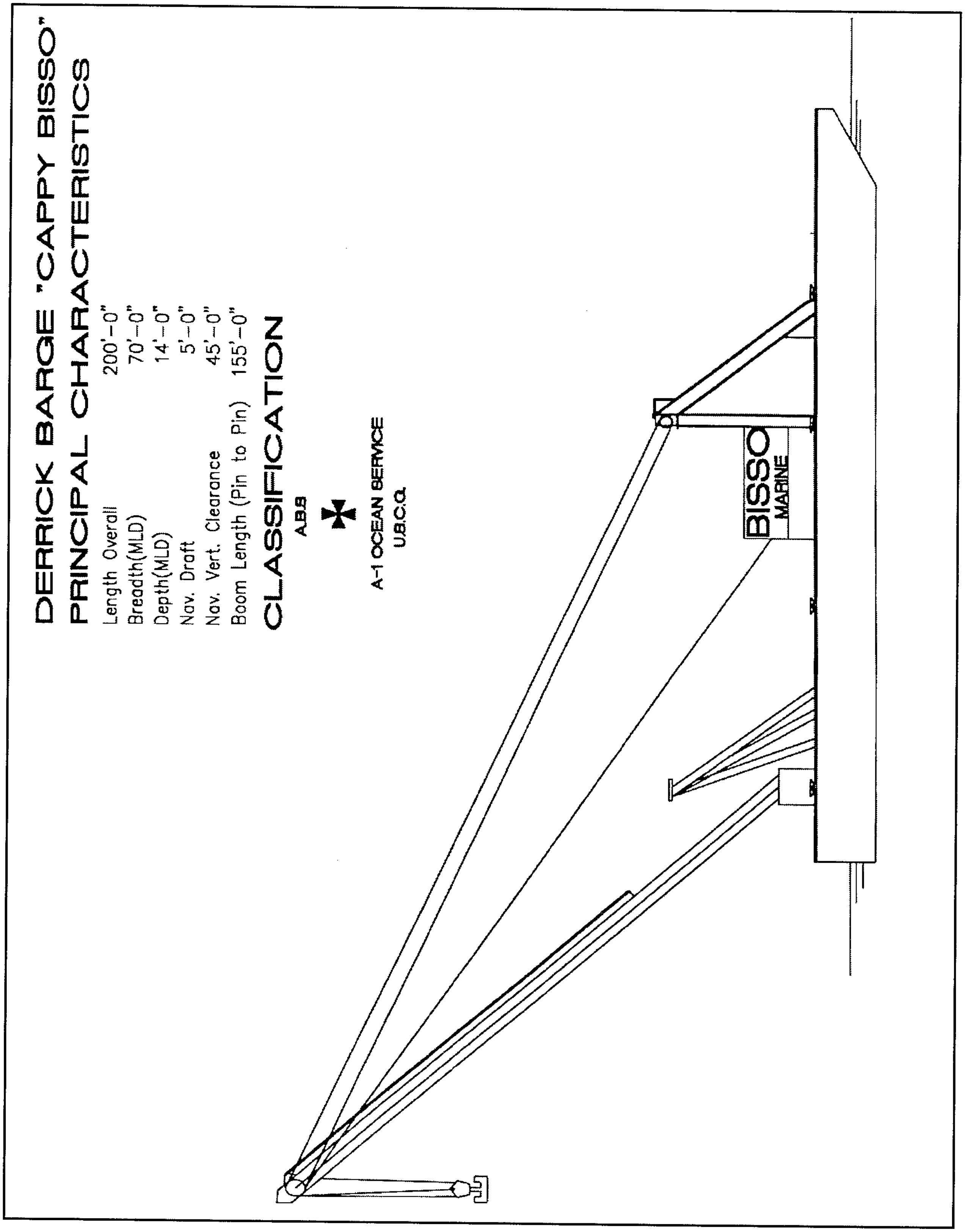
$15,000 per cal. day for 6 mo. rental
$12,500 per cal. day for 12 mo. rental
$10,000 per cal. day for 18 mo. rental

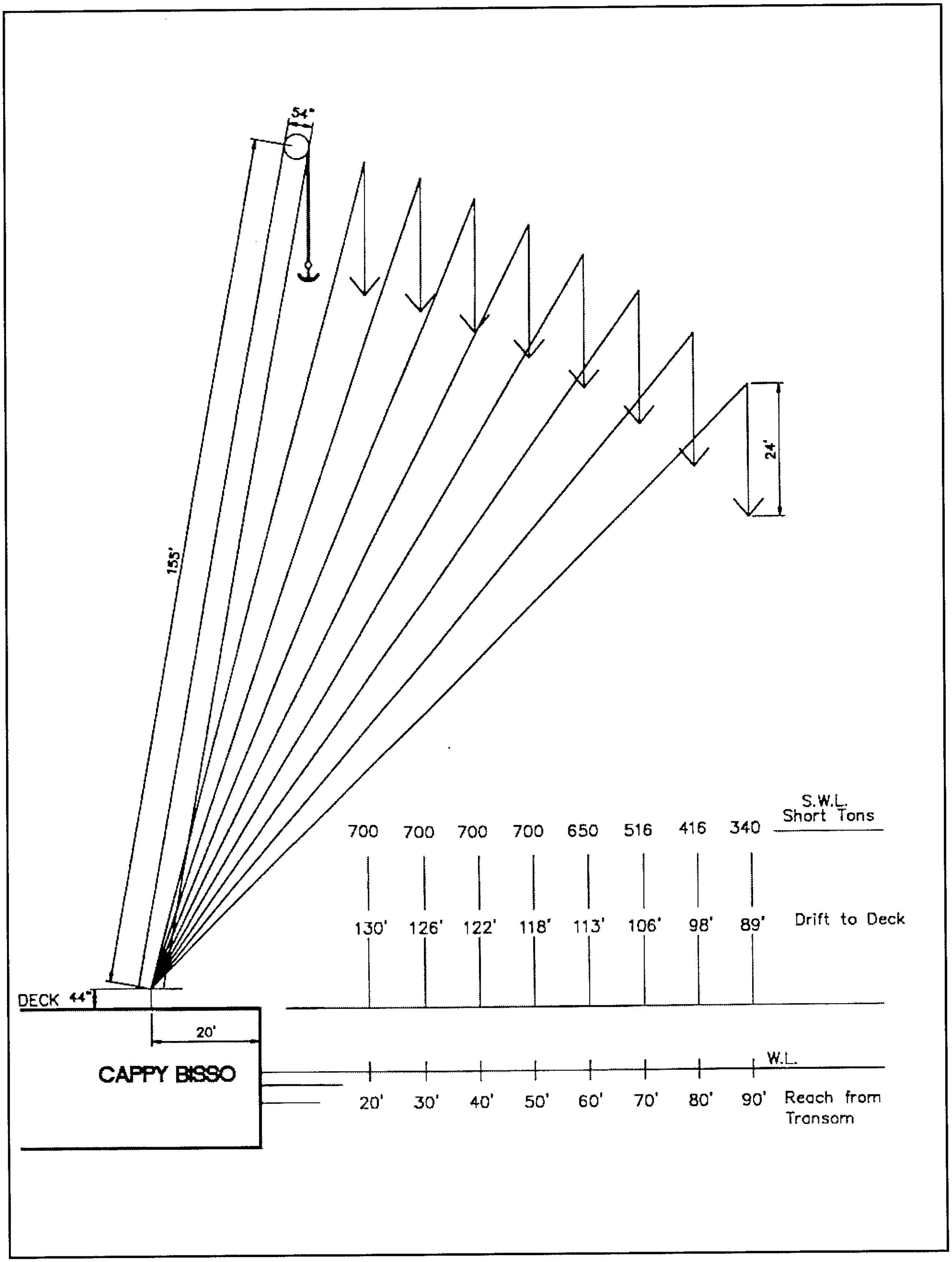
Cost to Rent/Lease Crane					
Lease 700 ton Derrick Barge	547.5 cal. Day @	$ 12,500	=	6,843,750	(rental rate suggesed by Bisso Marine with minimum rental)
Sales Tax on Lease				513,281	
Total Cost of Ownership =				*$ 7,357,031*	

Cost to Mobilize and Demobilize Crane Once		
Cost to deliver barge to site	65,000	(tug for 11 shifts at $5,000/shift, $10,000 general expenses)
Cost to deliver barge from site	65,000	(tug for 11 shifts at $5,000/shift, $10,000 general expenses)
Assemble and Dissassemble frames and rigging	65,000	(5 shifts to assmb., 4 shifts to dissassmb. $7,500 per shift)
Mobilization/Demob Cost =	*$ 195,000*	

Operating Cost				
Operators	1 ea x	2,880 hrs =	120,960	(Avg hrly labor cost is $42/hour)
Oilers	2 ea x	5,760 hrs =	184,320	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	4 ea x	11,520 hrs =	368,640	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, maint.	1 ea x	2,880 hrs =	57,600	(assume $20/hour fuel, oil. Lessor pays for maintenance)
Operating Cost =			*$ 610,560*	

Equipment Rental Cost =	7,357,031	
Mobilization & De-mobilization =	585,000	(cost is for 3 mob and demob)
Operating Costs =	731,520	
Total Crane Costs =	8,673,551	

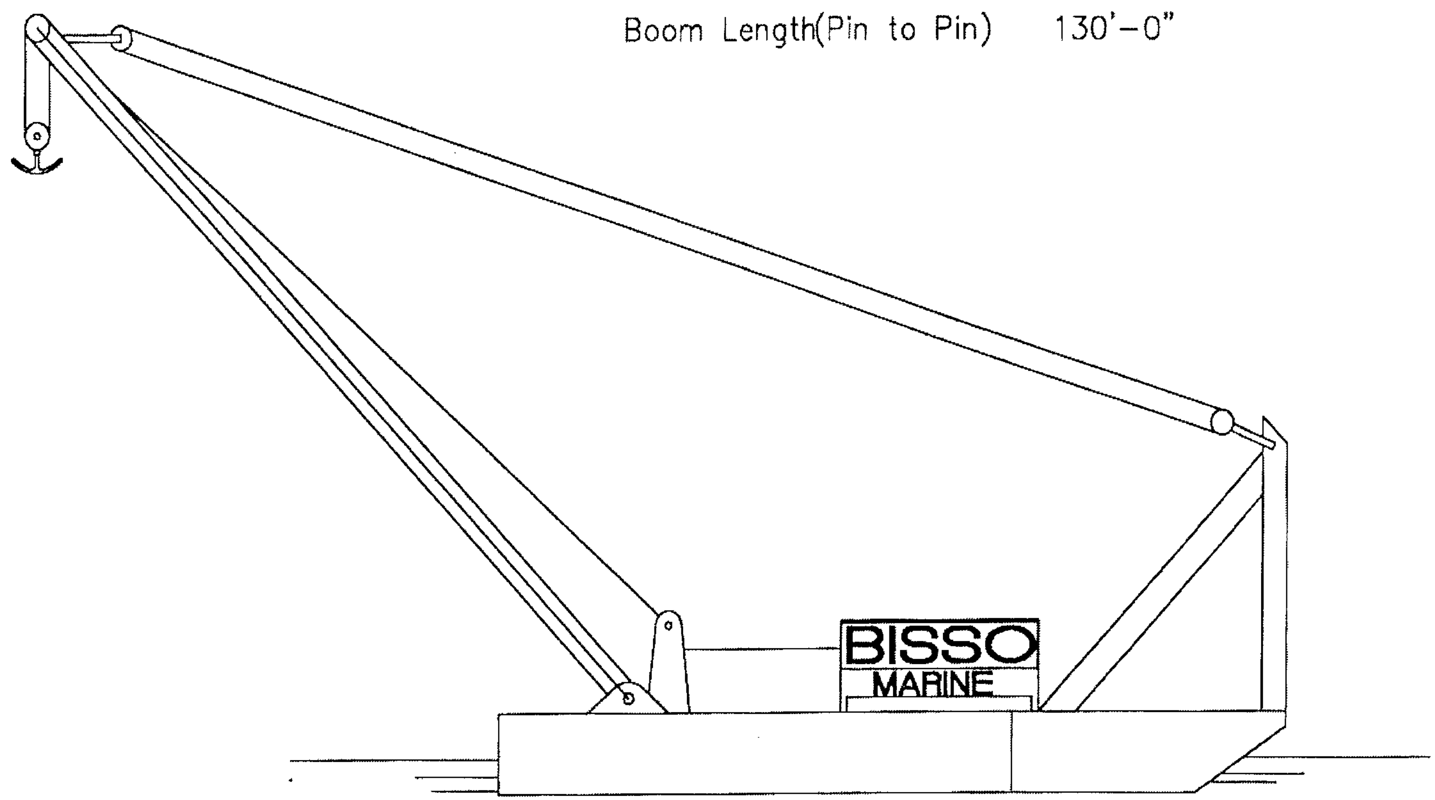

DERRICK BARGE "CAPPY BISSO"
PRINCIPAL CHARACTERISTICS
Length Overall 200'-0"
Breadth(MLD) 70'-0"
Depth(MLD) 14'-0"
Nav. Draft 5'-0"
Nav. Vert. Clearance 45'-0"
Boom Length (Pin to Pin) 155'-0"
CLASSIFICATION
A.B.S
A-1 OCEAN SERVICE
U.S.C.G.
BISSO
MARINE

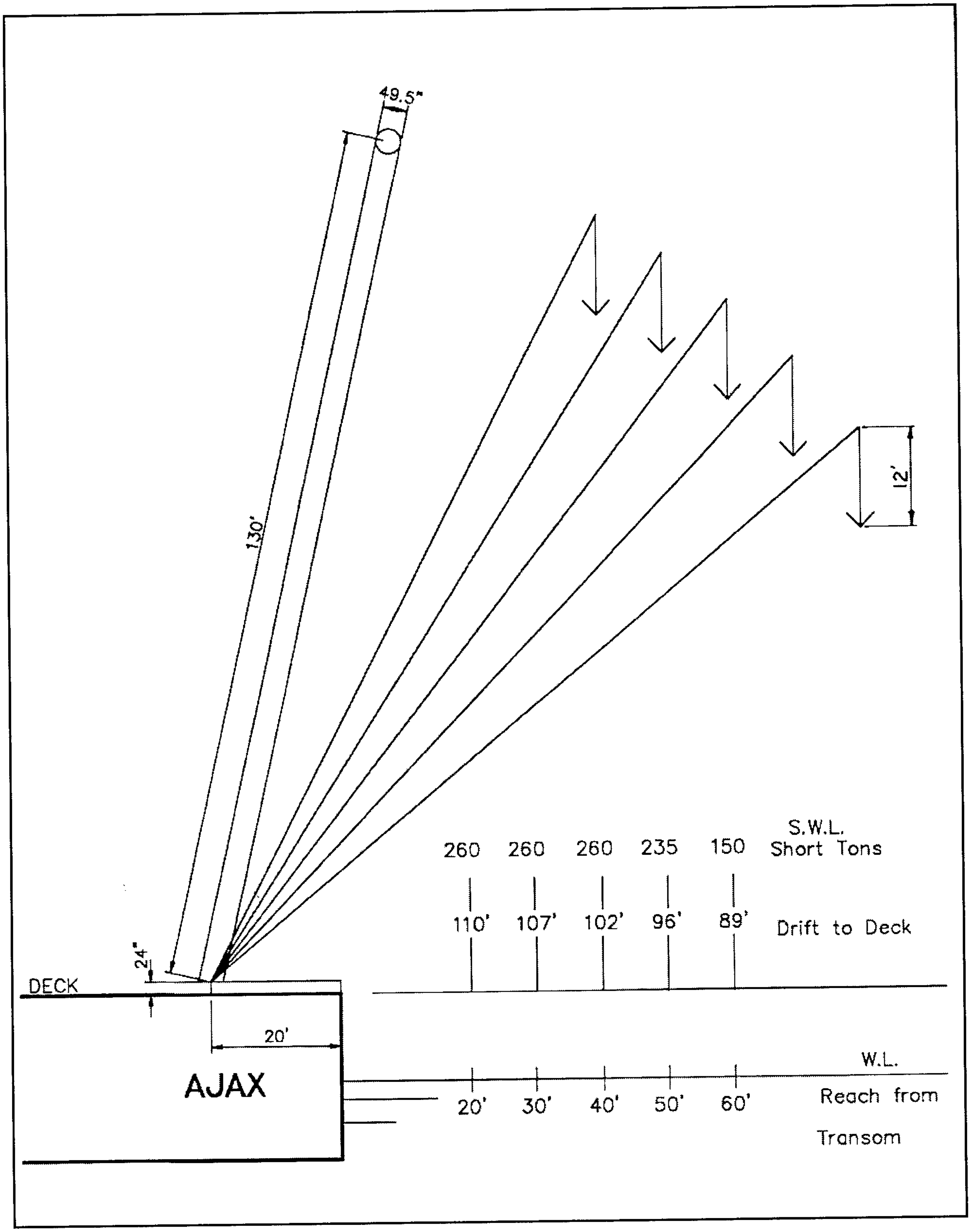


54"
155'
24'
S.W.L.
Short Tons
700
700
700
700
650
516
416
340
Drift to Deck
130'
126'
122'
118'
113'
106'
98'
89'
DECK 44"
20'
CAPPY BISSO
W.L.
20'
30'
40'
50'
60'
70'
80'
90'
Reach from
Transom

DERRICK BARGE "AJAX"
PRINCIPAL CHARACTERISTICS

Length Overall	121'–0"
Breadth(MLD)	65'–0"
Depth(MLD)	12'–0"
Nav. Draft	4'–0"
Nav. Vert. Clearance	50'–0"
Boom Length(Pin to Pin)	130'–0"




49.5"
130'
12'
24"
DECK
20'
AJAX
260
260
260
235
150
S.W.L.
Short Tons
110'
107'
102'
96'
89'
Drift to Deck
W.L.
20'
30'
40'
50'
60'
Reach from
Transom

DERRICK BARGE "LILI BISSO"

PRINCIPAL CHARACTERISTICS

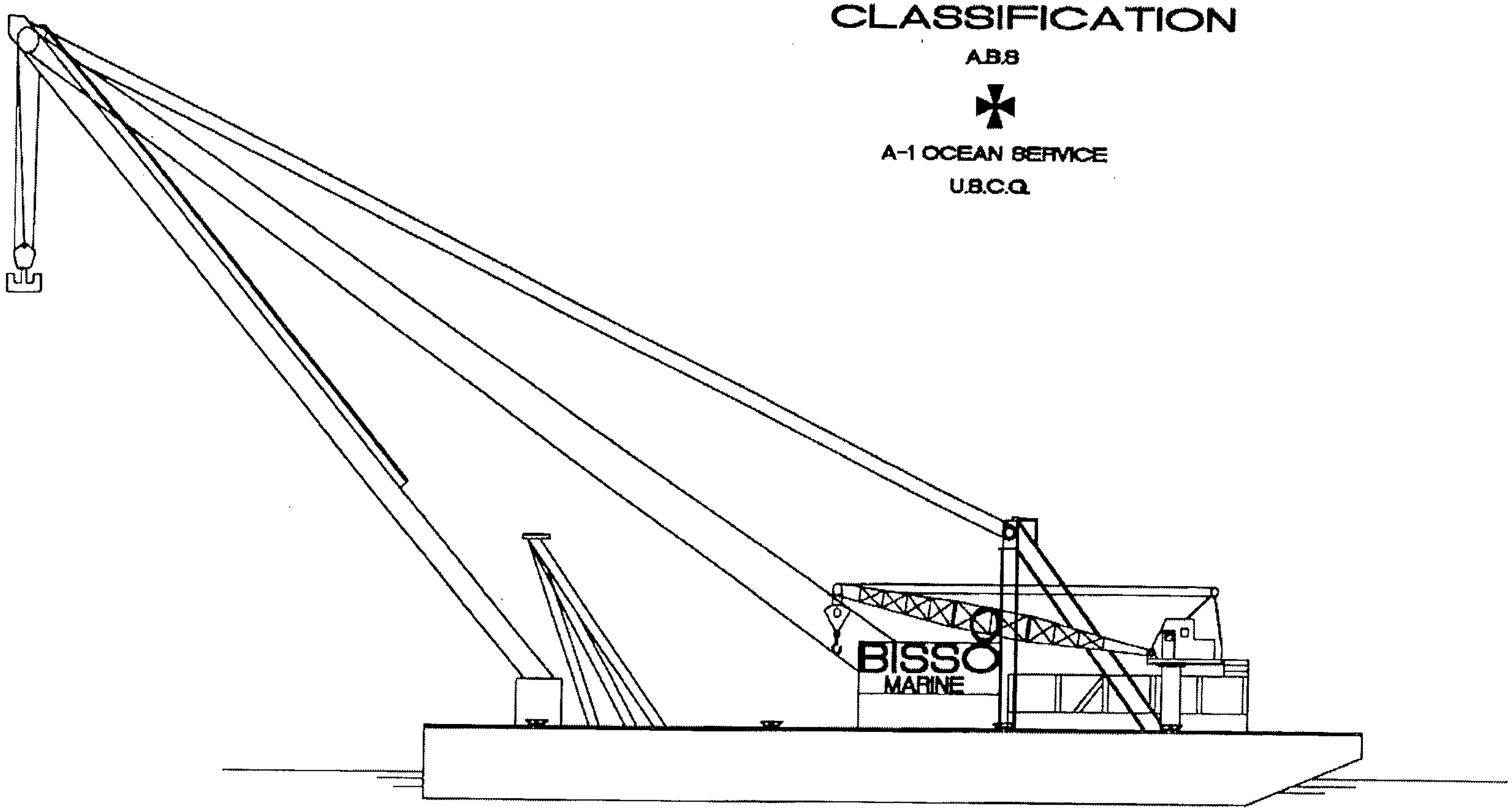
Length Overall	195'–0"
Breadth(MLD)	72'–0"
Depth(MLD)	13'–0"
Nav. Draft	5'–0"
Nav. Vert. Clearance	45'–0"
Boom Length(Pin to Pin)	155'–0"

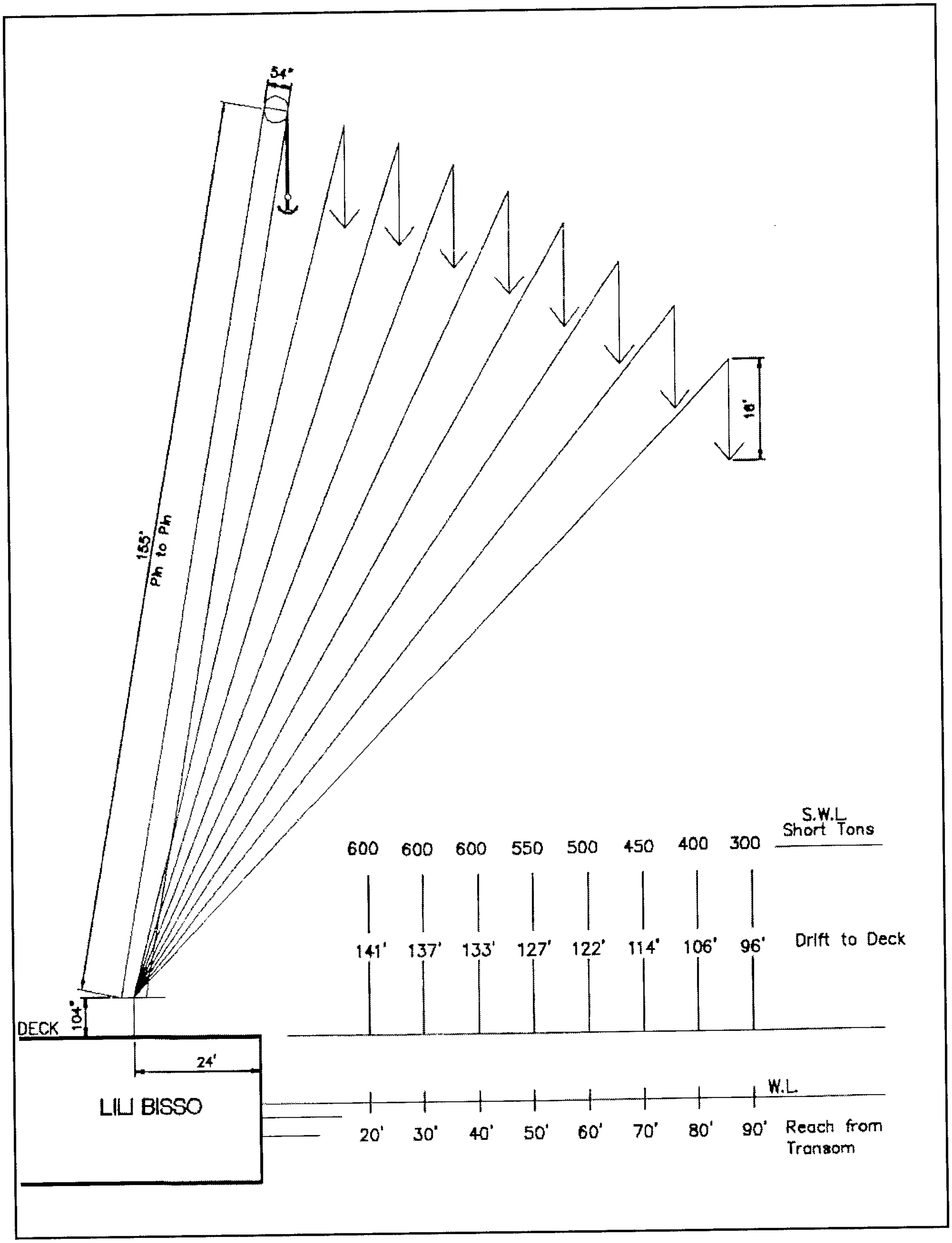
CLASSIFICATION

A.B.S

A-1 OCEAN SERVICE

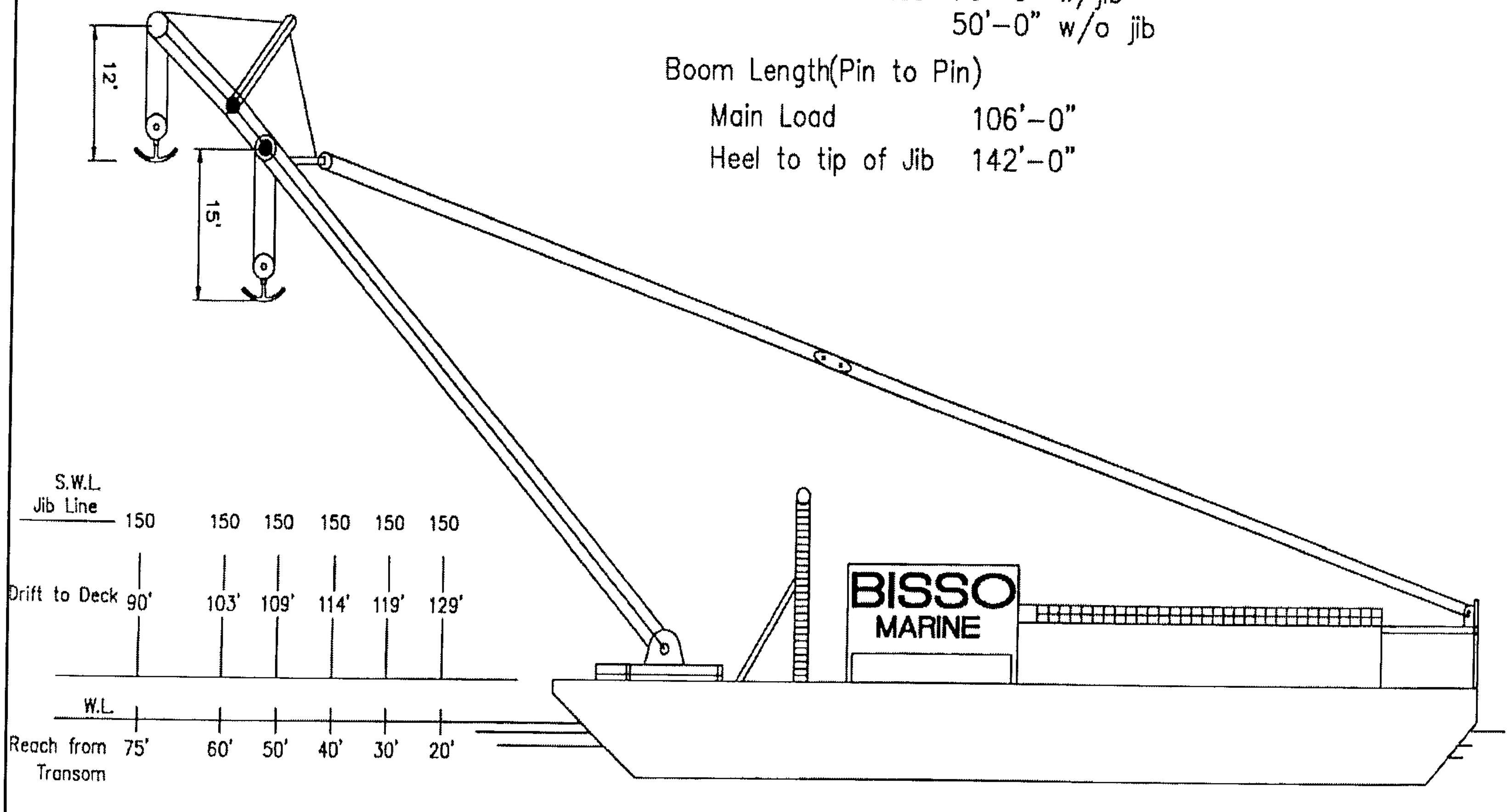
U.S.C.G.

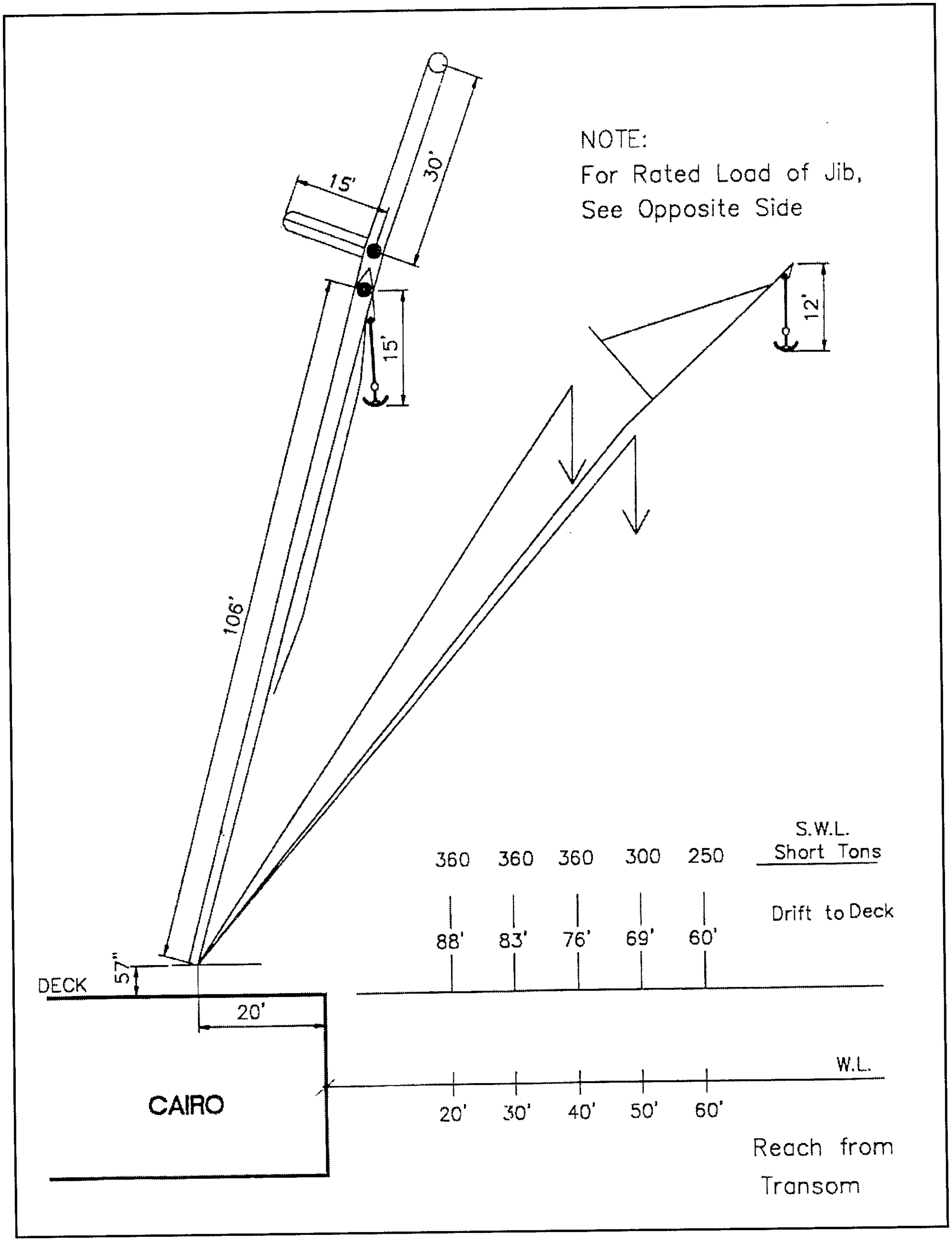



54"
155' Pin to Pin
16'
S.W.L. Short Tons
600
600
600
550
500
450
400
300
Drift to Deck
141'
137'
133'
127'
122'
114'
106'
96'
DECK
104"
24'
LILI BISSO
W.L.
20'
30'
40'
50'
60'
70'
80'
90'
Reach from Transom

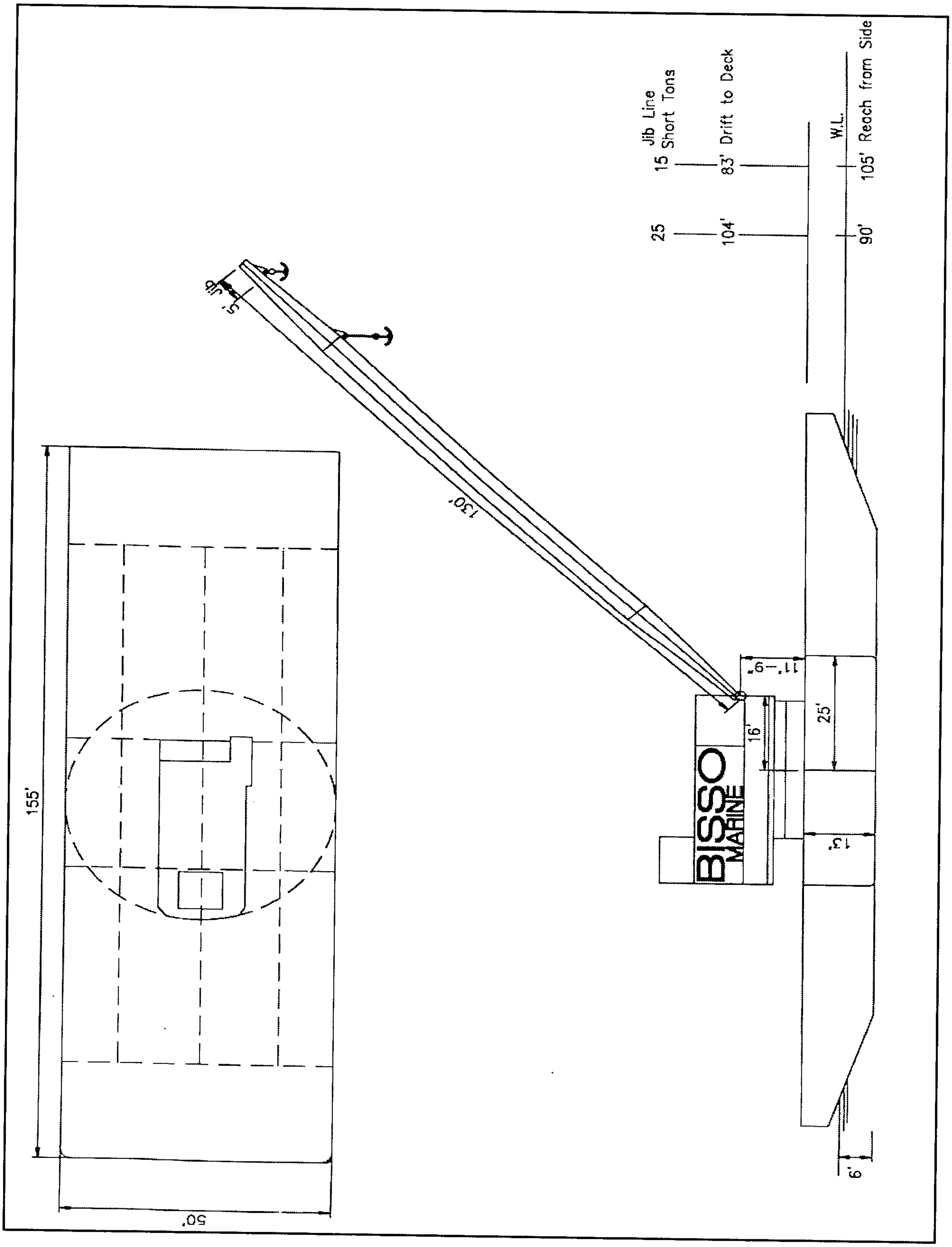
DERRICK BARGE "CAIRO"
PRINCIPAL CHARACTERISTICS

Length Overall	165'–0"
Breadth(MLD)	70'–0"
Depth(MLD)	14'–0"
Nav. Draft	6'–0"
Nav. Vert. Clearance	70'–0" w/jib
	50'–0" w/o jib
Boom Length(Pin to Pin)	
Main Load	106'–0"
Heel to tip of Jib	142'–0"





NOTE:
For Rated Load of Jib,
See Opposite Side
15'
30'
15'
12'
106'
360
360
360
300
250
S.W.L.
Short Tons
Drift to Deck
88'
83'
76'
69'
60'
DECK
57"
20'
CAIRO
W.L.
20'
30'
40'
50'
60'
Reach from
Transom


Jib Line
15 Short Tons
25
83' Drift to Deck
104'
W.L.
105' Reach from Side
90'
5' Jib
130'
155'
50'
11'-9"
16'
25'
13'
6'
BISSO
MARINE

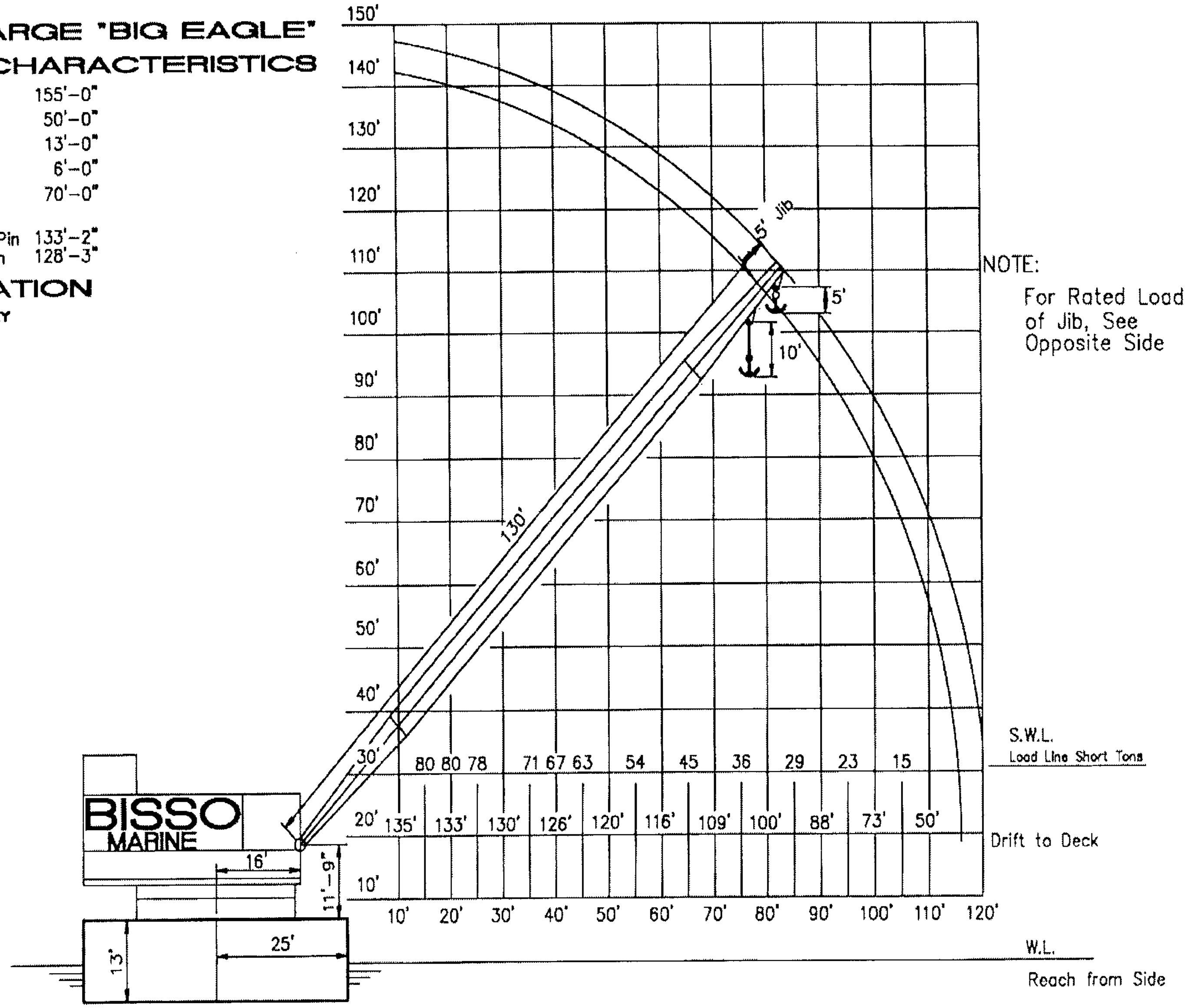
DERRICK BARGE "BIG EAGLE"

PRINCIPAL CHARACTERISTICS

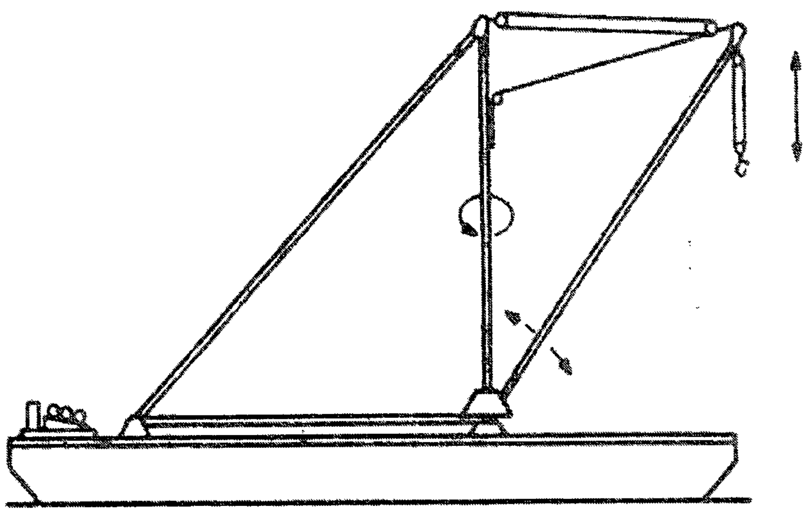
Length Overall	155'-0"
Breadth(MLD)	50'-0"
Depth(MLD)	13'-0"
Nav. Draft	6'-0"
Nav. Vert. Clearance	70'-0"
Boom Length:	
Heel Pin to Light Load Pin	133'-2"
Heel Pin to Big Load Pin	128'-3"

CLASSIFICATION

A.B.S LOAD LINE ONLY

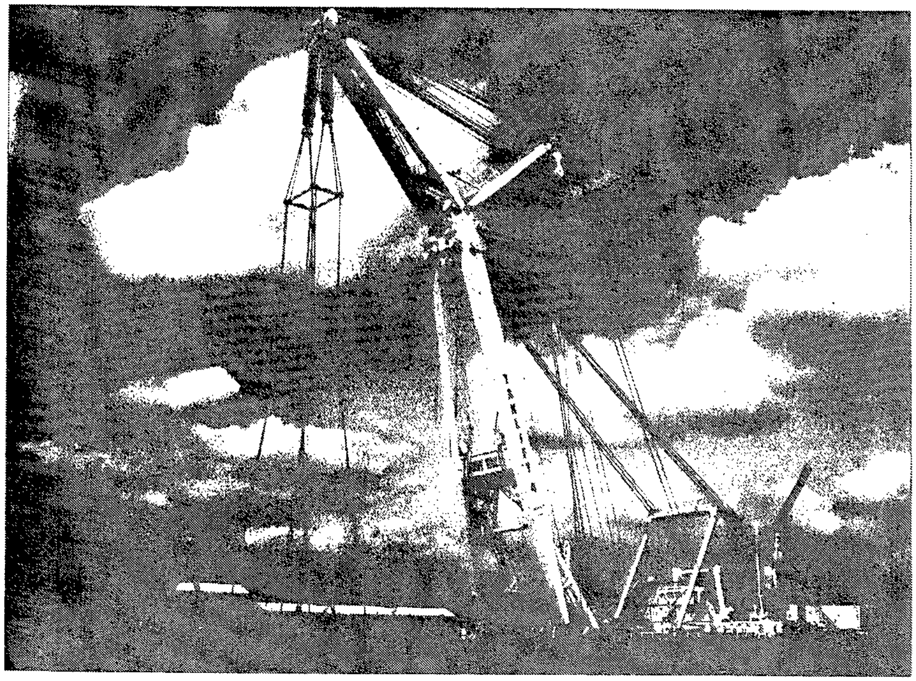


Appendix C
Technical Data and Cost Estimates on Offshore Shear-Leg Crane Barges



Stiffleg Derrick Crane

TAKLIFT 4
SEAGOING FLOATING SHEERLEGS
1600/2400 TONNES LIFTING CAPACITY



Call sign
PHWS

Classification
Lloyds ✠ 100 A 1 L.M.C. + LA

Year of Construction
1981

Dimensions

Length o.a.	83.10 m
Beam extreme	35.47 m
Beam pontoon	28.24 m
Depth	7.00 m
Draught	2.60 m
Sailing height at sea	24.70 m
Sailing height inland	28.00 m
Gross tonnage	4854 R.T.
Nett tonnage	1456 R.T.

Accommodation
30 persons

Propulsion
2 x 839 kW

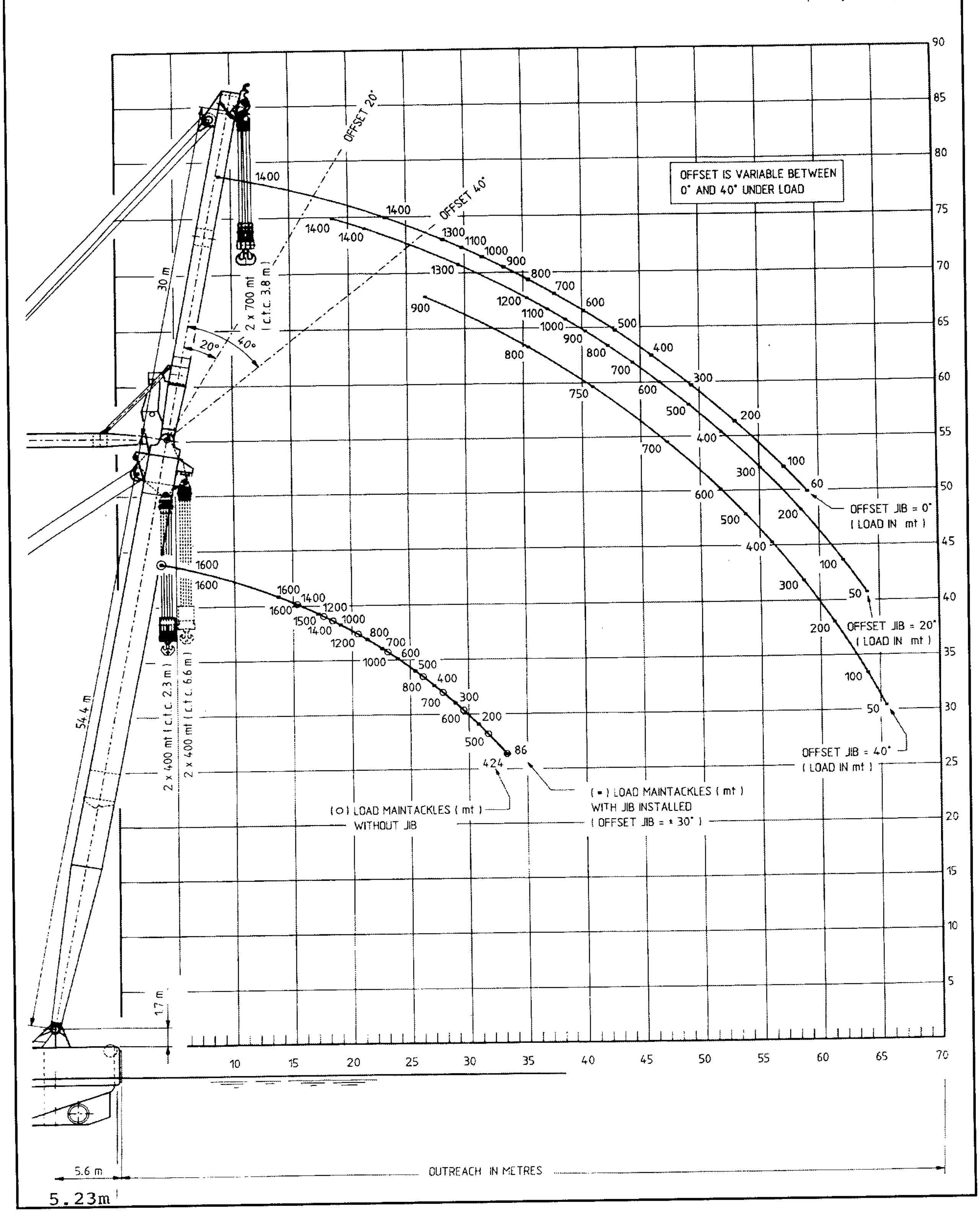
Anchor winches
Aft : 1 x 40/25 T winch with cap. for 385 m of ø 62 mm chain
Forward: 1 x 40/25 T winch with cap. for 385 m of ø 62 mm chain

Mooring winches
Aft:
2 x 40/15 T winches with cap. for 550 m of ø 44 mm wire rope
1 x 40/25 T winch with cap. for 500 m of ø 38 mm wire rope
2 x 40 T winches with cap. for 625 m of ø 48 mm wire rope
Forward:
2 x 40/25 T winches with cap. for 550 m of ø 44 mm wire rope
2 x 40/25 T winches with cap. for 500 m of ø 38 mm wire rope
2 x 68 T winches with cap. for 550 m of ø 48 mm wire rope

Lift capacity
For capacity lifting upto 2400 T, see diagram
For capacity lifting above 950 T. in flyjib. side pontoons have to be mounted, increasing the beam extreme to 39,9 m
Dimensions of side pontoons are:
L x B x H = 38 x 5,8 x 4 m with own weight of 120 T each

Smit International
Zalmstraat 1, 3016 DS Rotterdam
P.O. Box 1042, 3000 BA Rotterdam
The Netherlands

Main sheerlegs and flyjib tackles can operate simultaneously.
Load capacity on request.



Appendix C

Cost Analysis, Purchasing 2,000 Ton Offshore Crane Barge (1 year, 100% Usage)

Assumed duration of heavy lift crane	1.0	years
Months out of each year crane operates	12	months per year
Cost of capital (interest rate)	8.0	percent
Sales Tax Rate	0.0	percent
Total Depreciation	25.0	percent

Cost to Purchase Crane Barge

Purchase Hull (300' x 105' x 18' @ 125 psf)	$	4,950,000	(hull weight is 3,950,000 lbs. Assume barge complete is $1.25/lb)
Structural Outfitting	$	800,000	
Mechanical Systems	$	390,000	
Electrical Systems	$	554,000	
Derrick Crane	$	5,000,000	
Engineering and yard services	$	900,000	
Mooring Equipment	$	1,000,000	
Total Purchase Cost (including sales tax) =	$	13,594,000	(estimate based on Glosten Associates 4/14/97 estimate).
Cost of Capital for duration of lift crane use	$	1,087,520	
Depreciation Cost (Sell vessel intact at some % of new)	$	3,398,500	
Cost of Ownership	$	*4,486,020*	

Cost to Mobilize and De-Mobilize Derrick Barge Once

Cost to deliver barge to site		250,000	allowance
Cost to deliver barge from site		250,000	allowance
Make-ready at site		125,000	(say 10 sh to at $7,500 per shift)
Mobilization/Demob Cost	$	*625,000*	

Cost to Operate Crane

Operators	2	each x	3,840	hrs =		161,280	(Avg hrly labor cost is $42/hour)
Oilers	3	each x	5,760	hrs =		184,320	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	7	each x	13,440	hrs =		430,080	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1	each x	1,920	hrs =		153,600	(assume $20/hr fuel, oil, plus $60/hour in parts and mechanic time)
Operations Cost					$	*929,280*	

Equipment Rental Cost =	4,486,020	
Mobilization & De-mobilization =	625,000	(cost is for 1 mob and demob)
Operating Costs =	929,280	
Total Crane Costs =	6,040,300	

Appendix C

Cost Analysis, Purchasing 2,000 Ton Offshore Crane Barge (2 year, 50% Usage)

Assumed duration of heavy lift crane	2.0	years
Months out of each year crane operates	6	months per year
Cost of capital (interest rate)	8.0	percent
Sales Tax Rate	0.0	percent
Total Depreciation	30.0	percent

Cost to Purchase Crane Barge			
Purchase Hull (300' x 105' x 18' @ 125 psf)	$	4,950,000	(hull weight is 3,950,000 lbs. Assume barge complete is $1.25/lb)
Structural Outfitting	$	800,000	
Mechanical Systems	$	390,000	
Electrical Systems	$	554,000	
Derrick Crane	$	5,000,000	
Engineering and yard services	$	900,000	
Mooring Equipment	$	1,000,000	
Total Purchase Cost (including sales tax) =	$	13,594,000	(estimate based on Glosten Associates 4/14/97 estimate).
Cost of Capital for duration of lift crane use	$	2,262,042	
Depreciation Cost (Sell vessel intact at some % of new)	$	4,078,200	
Cost of Ownership	$	6,340,242	

Cost to Mobilize and De-Mobilize Derrick Barge Once			
Cost to deliver barge to site		250,000	allowance
Cost to deliver barge from site		250,000	allowance
Make-ready at site		125,000	(say 10 sh to at $7,500 per shift)
Mobilization/Demob Cost	$	625,000	

Cost to Operate Crane						
Operators	2 each x	3,840	hrs =		161,280	(Avg hrly labor cost is $42/hour)
Oilers	3 each x	5,760	hrs =		184,320	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	7 each x	13,440	hrs =		430,080	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1 each x	1,920	hrs =		153,600	(assume $20/hr fuel, oil, plus $60/hour in parts and mechanic time)
Operations Cost				$	929,280	

Equipment Rental Cost =	6,340,242	
Mobilization & De-mobilization =	625,000	(cost is for 1 mob and demob)
Operating Costs =	929,280	
Total Crane Costs =	7,894,522	

Appendix C

Cost Analysis, Purchasing 2,000 Ton Offshore Crane Barge (3 year, 50% Usage)

Assumed duration of heavy lift crane	3.0	years
Months out of each year crane operates	6	months per year
Cost of capital (interest rate)	8.0	percent
Sales Tax Rate	0.0	percent
Total Depreciation	35.0	percent

Cost to Purchase Crane Barge

Purchase Hull (300' x 105' x 18' @ 125 psf)	$	4,950,000	(hull weight is 3,950,000 lbs. Assume barge complete is $1.25/lb)
Structural Outfitting	$	800,000	
Mechanical Systems	$	390,000	
Electrical Systems	$	554,000	
Derrick Crane	$	5,000,000	
Engineering and yard services	$	900,000	
Mooring Equipment	$	1,000,000	
Total Purchase Cost (including sales tax) =	$	13,594,000	(estimate based on Glosten Associates 4/14/97 estimate).
Cost of Capital for duration of lift crane use	$	3,530,525	
Depreciation Cost (Sell vessel intact at some % of new)	$	4,757,900	
Cost of Ownership	$	*8,288,425*	

Cost to Mobilize and De-Mobilize Derrick Barge Once

Cost to deliver barge to site		250,000	allowance
Cost to deliver barge from site		250,000	allowance
Make-ready at site		125,000	(say 10 sh to at $7,500 per shift)
Mobilization/Demob Cost	$	*625,000*	

Cost to Operate Crane

Operators	2 each x	5,760	hrs =		241,920	(Avg hrly labor cost is $42/hour)
Oilers	3 each x	8,640	hrs =		276,480	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	7 each x	20,160	hrs =		645,120	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1 each x	2,880	hrs =		230,400	(assume $20/hr fuel, oil, plus $60/hour in parts and mechanic time)
Operations Cost				$	*1,393,920*	

Equipment Rental Cost =	8,288,425	
Mobilization & De-mobilization =	625,000	(cost is for 1 mob and demob)
Operating Costs =	1,393,920	
Total Crane Costs =	10,307,345	

Appendix C

Cost Analysis, Leasing 2,000 Ton Offshore Sheer Leg Crane Barge (Taklift 4) (1 year, 100% Usage)

Assumed duration of heavy lift crane	1.0	years	
Months out of each year crane operates	12	months per year	6 month minimum rental period
Number of Mobilizations	1	each	
Cost of capital (interest rate)	8.0	percent	
Sales Tax Rate	7.5	percent	
Total Depreciation	0.0	percent	

Cost to Lease Taklift 4			
Lease Payment =	600,000	per month	
Total Lease Cost =			7,200,000
Sales Tax on Lease			540,000
Cost of Ownership			*$ 7,740,000*

Cost to Mobilize and De-Mobilize Derrick Barge Once		
Cost to deliver barge to site	350,000	allowance
Cost to deliver barge from site	350,000	allowance
Mobilization/Demob	*$ 700,000*	

Cost to Operate Crane				
Operators	2 each x	3,840	161,280	(Avg hrly labor cost is $42/hour)
Oilers	3 each x	5,760	184,320	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	7 each x	13,440	430,080	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1 each x	1,920	153,600	(assume $20/hour fuel, oil, and grease pluse $60/hour in parts and mechanic time)
Operations Cost			*$ 929,280*	

Equipment Rental Cost =	7,740,000	
Mobilization & De-mobilization =	700,000	(cost is for 1 mob and demob since the crane is purchased and remains on job)
Operating Costs =	929,280	
Total Crane Costs =	9,369,280	

Appendix C

Cost Analysis, Leasing 2,000 Ton Offshore Sheer Leg Crane Barge (Taklift 4) (2 year, 50% Usage)

Assumed duration of heavy lift crane	2.0	years	
Months out of each year crane operates	6	months per year	6 month minimum rental period
Number of Mobilizations	2	each	
Cost of capital (interest rate)	8.0	percent	
Sales Tax Rate	7.5	percent	
Total Depreciation	0.0	percent	

Cost to Lease Taklift 4

Lease Payment =	600,000	per month	
Total Lease Cost =			7,200,000
Sales Tax on Lease			540,000
Cost of Ownership			$ *7,740,000*

Cost to Mobilize and De-Mobilize Derrick Barge Once

Cost to deliver barge to site	350,000	allowance
Cost to deliver barge from site	350,000	allowance
Mobilization/Demob	$ *700,000*	

Cost to Operate Crane

Operators	2 each x	3,840	161,280	(Avg hrly labor cost is $42/hour)
Oilers	3 each x	5,760	184,320	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	7 each x	13,440	430,080	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1 each x	1,920	153,600	(assume $20/hour fuel, oil, and grease pluse $60/hour in parts and mechanic time)
Operations Cost			$ *929,280*	

Equipment Rental Cost =	7,740,000	
Mobilization & De-mobilization =	1,400,000	(cost is for 2 mob and demob since the crane is purchased and remains on job)
Operating Costs =	929,280	
Total Crane Costs =	10,069,280	

Appendix C

Cost Analysis, Leasing 2,000 Ton Offshore Sheer Leg Crane Barge (Taklift 4) (3 year, 50% Usage)

Assumed duration of heavy lift crane	3.0	years	
Months out of each year crane operates	6	months per year	6 month minimum rental period
Number of Mobilizations	3	each	
Cost of capital (interest rate)	8.0	percent	
Sales Tax Rate	7.5	percent	
Total Depreciation	0.0	percent	

Cost to Lease Taklift 4

Lease Payment =	600,000	per month	
Total Lease Cost =			10,800,000
Sales Tax on Lease			810,000
Cost of Ownership			*$ 11,610,000*

Cost to Mobilize and De-Mobilize Derrick Barge Once

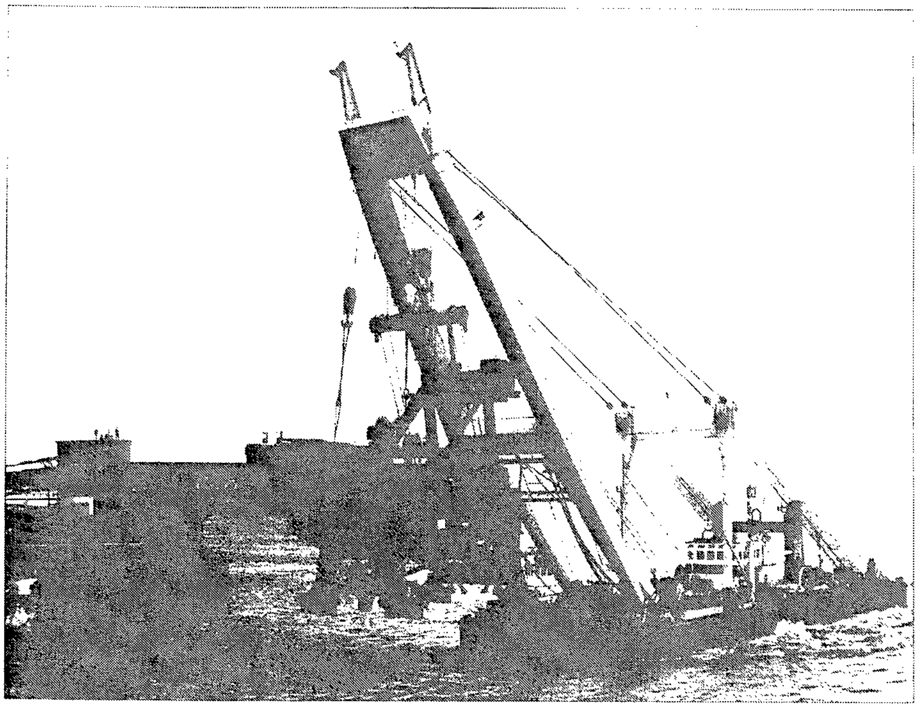
Cost to deliver barge to site	350,000	allowance
Cost to deliver barge from site	350,000	allowance
Mobilization/Demob	*$ 700,000*	

Cost to Operate Crane

Operators	2 each x	5,760	241,920	(Avg hrly labor cost is $42/hour)
Oilers	3 each x	8,640	276,480	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	7 each x	20,160	645,120	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1 each x	2,880	230,400	(assume $20/hour fuel, oil, and grease pluse $60/hour in parts and mechanic time)
Operations Cost			*$ 1,393,920*	

Equipment Rental Cost =	11,610,000	
Mobilization & De-mobilization =	2,100,000	(cost is for 3 mob and demob since the crane is purchased and remains on job)
Operating Costs =	1,393,920	
Total Crane Costs =	15,103,920	

TAKLIFT 1
SEAGOING FLOATING SHEERLEGS
800/1100 TONNES LIFTING CAPACITY



Call sign
PHWR

Classification
Bureau Veritas I
3/3 d ✣ coastal service
deepsea towed pontoon

Year of Construction
1969

Dimensions

Length o.a.	60.35 m
Beam	23.80 m
Depth	5.60 m
Draught	2.90 m
Sailing height at sea	19.10 m
Sailing height inland	11.80 m
Gross tonnage	2308.00 R.T.
Nett tonnage	893.30 R.T.

Accommodation
21 persons

Propulsion
2 x 390 kW

Bowthruster
1 x 162 kW

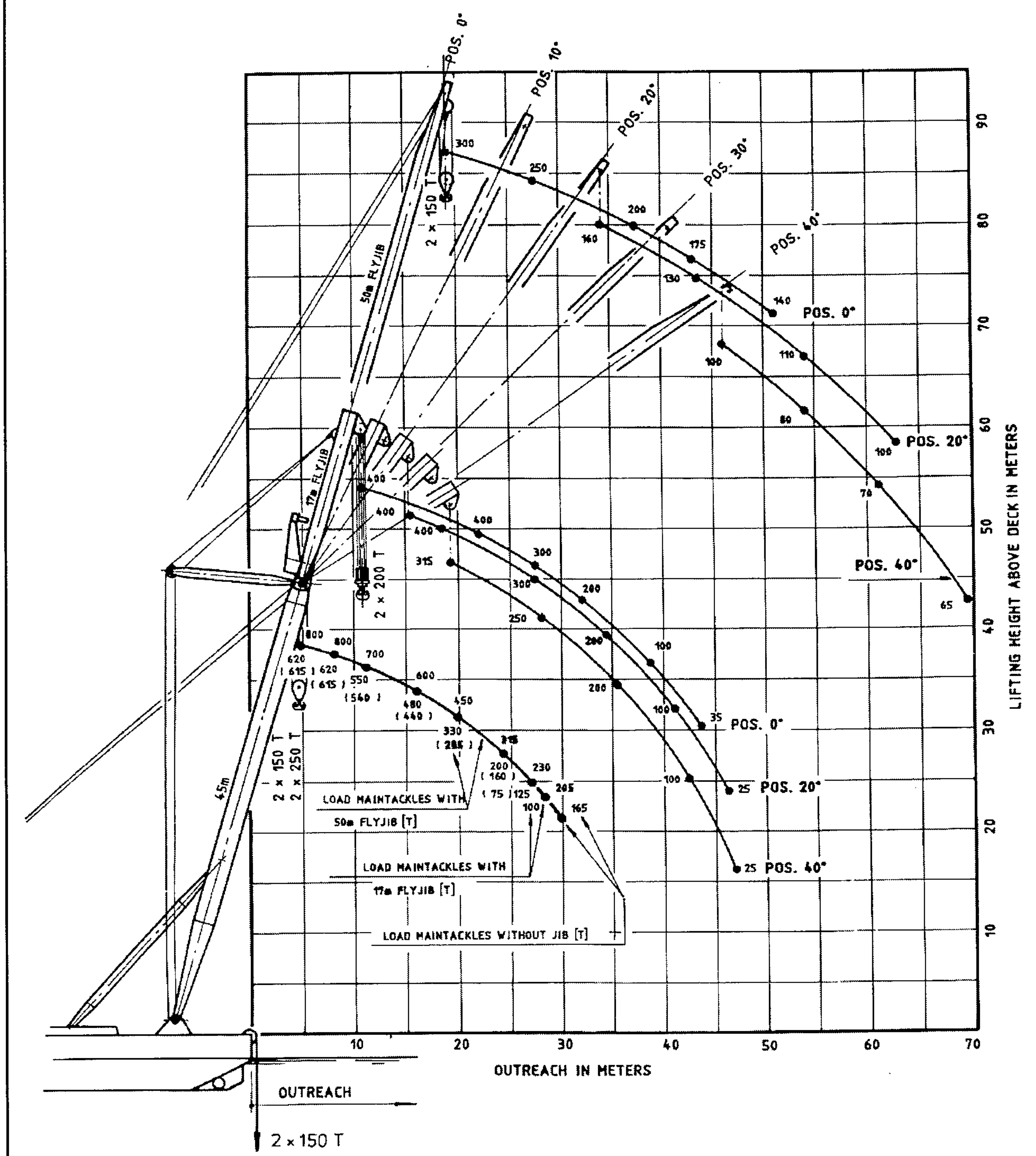
Anchor winches
Aft:
1 x 12,5 T winch with cap. for 275 m of ø 62 mm chain
Forward:
1 x 12,5 T winch with cap. for 275 m of ø 62 mm chain

Mooring winches
Aft:
3 x 12,5 T winches with cap. for 250 m of ø 38 mm wire rope
Forward:
5 x 12,5 T winches with cap. for 250 m of ø 38 mm wire rope

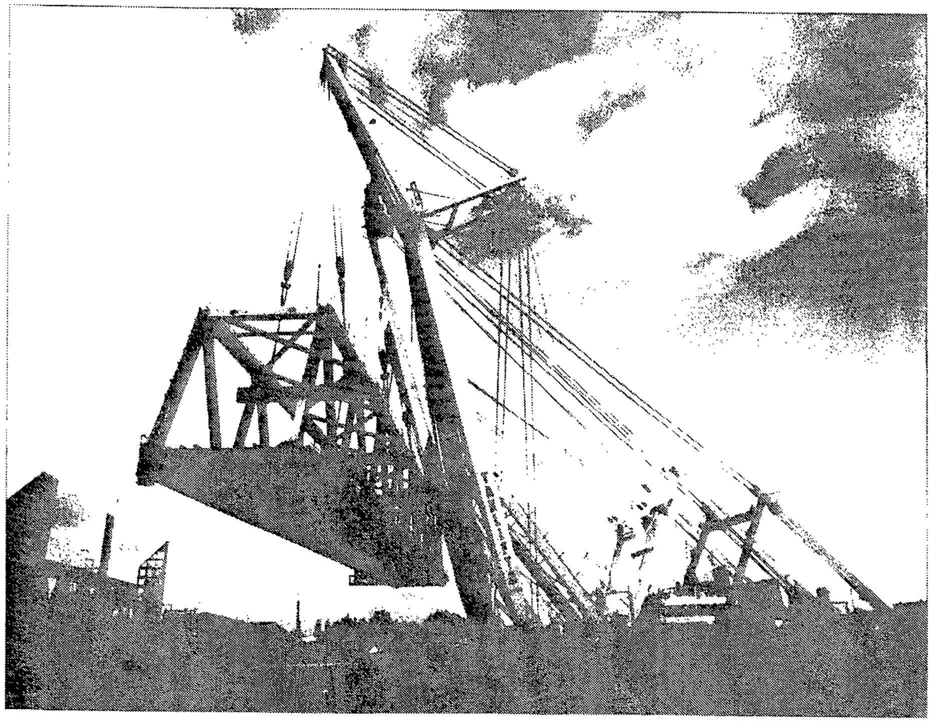
Lift capacity
See diagram

Smit International
Zalmstraat 1, 3016 DS Rotterdam
P.O. Box 1042, 3000 BA Rotterdam
The Netherlands

Main sheerlegs and flyjib tackles can operate simultaneously.
Load capacity on request.



TAKLIFT 3
SEAGOING FLOATING SHEERLEGS
400 TONNES LIFTING CAPACITY



Call sign
PHWY

Classification
GL ✣ 100 A4

Year of Construction
1967

Dimensions

Length o.a.	46.44 m
Beam	20.00 m
Depth	3.60 m
Draught	1.60 m
Sailing height at sea	16.00 m
Sailing height inland	6.90 m
Gross tonnage	1001.62 R.T.
Nett tonnage	641.88 R.T.

Accommodation
13 persons

Propulsion
2 x 240 kW

Anchor winches
Aft :
2 x 6,8 T winch with cap. for 275 m of ø 38 mm chain
Forward :
1 x 12,5 T winch with cap. for 180 m of ø 40 mm chain

Mooring winches
Aft :
3 x 10/5 T winches with cap. for 250 m of ø 28 mm wire rope
Forward :
2 x 10/5 T winches with cap. for 250 m of ø 28 mm wire rope

Lift capacity
See diagram

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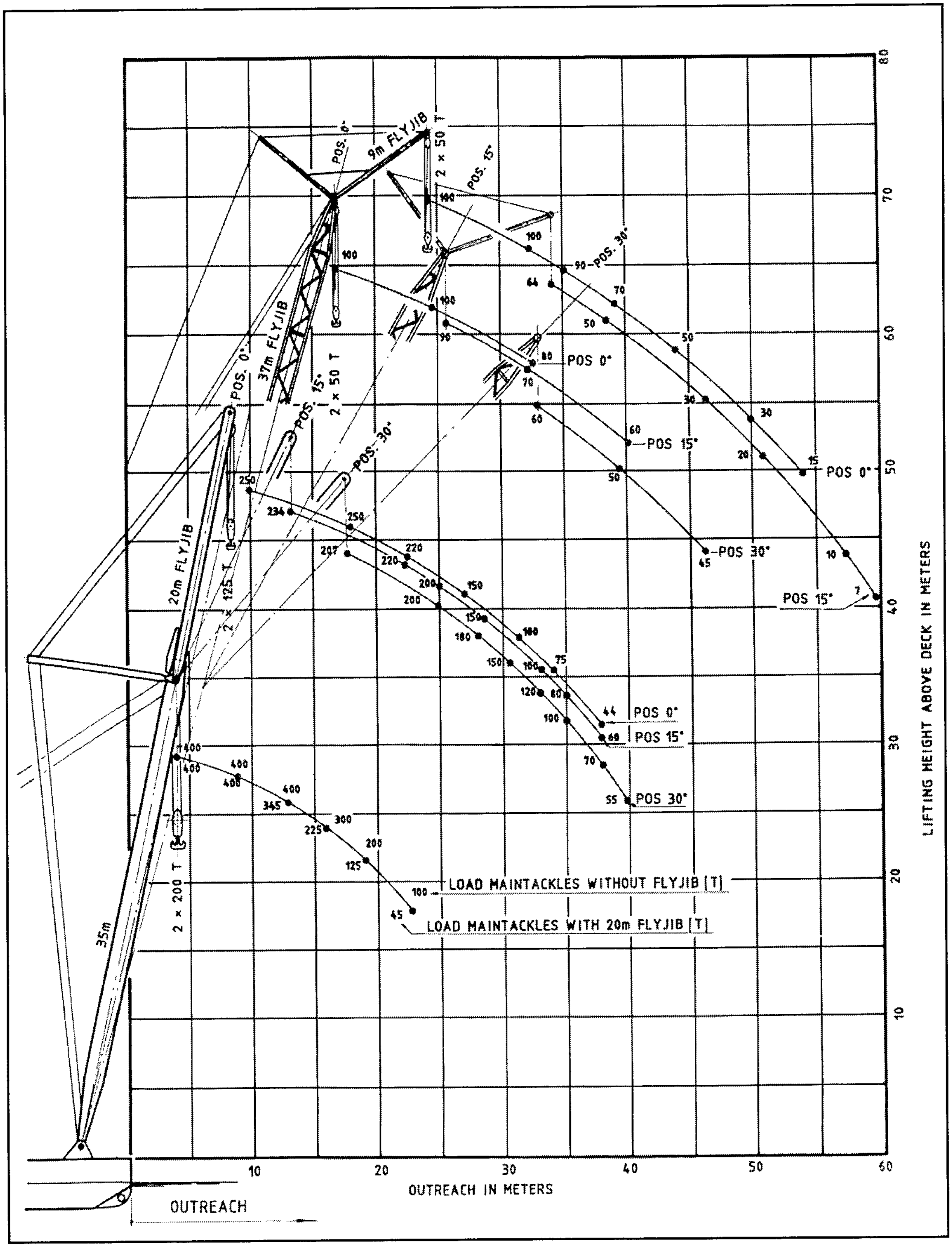
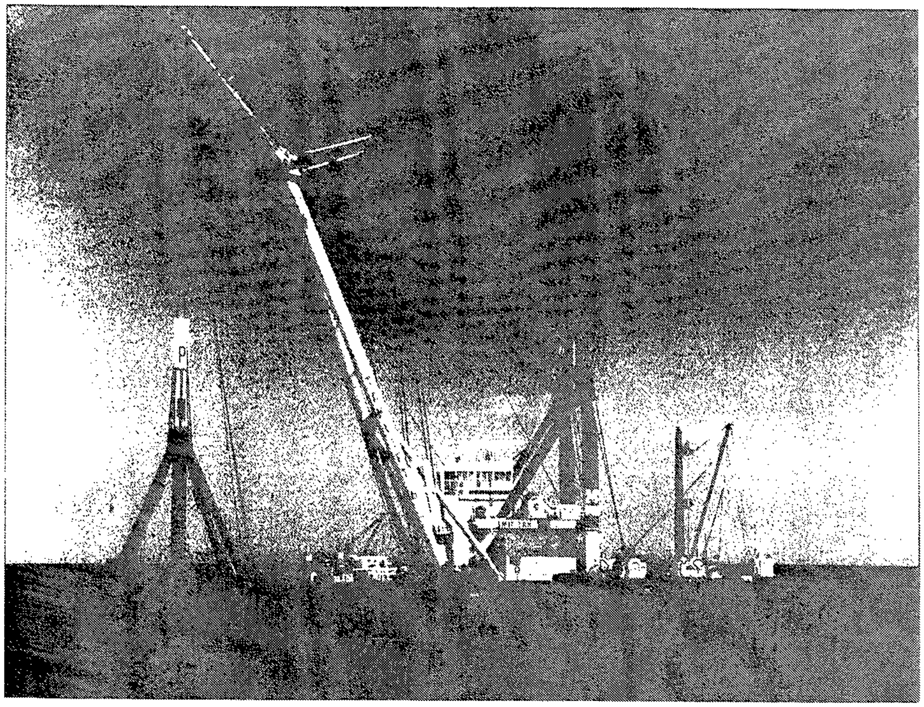

9m FLYJIB
2 × 50 T
POS. 0°
POS. 15°
POS. 30°
37m FLYJIB
2 × 50 T
20m FLYJIB
2 × 125 T
2 × 200 T
35m
POS 0°
POS 15°
POS 30°
LOAD MAINTACKLES WITHOUT FLYJIB [T]
LOAD MAINTACKLES WITH 20m FLYJIB [T]
OUTREACH IN METERS
LIFTING HEIGHT ABOVE DECK IN METERS
OUTREACH

TAKLIFT 6
SEAGOING FLOATING SHEERLEGS
1200/1600 TONNES LIFTING CAPACITY



Call sign
C6KS5

Classification
GL ✠ 100 A4 MC

Year of Construction
1975

Dimensions

Length o.a.	72.56 m
Beam	30.50 m
Depth	5.50 m
Draught	2.50 m
Sailing height at sea	40.00 m
Sailing height inland	40.00 m
Gross tonnage	3297 R.T.
Nett tonnage	989 R.T.

Accommodation
32 persons

Propulsion
2 x 460 kW

Anchor winches
Aft:
1 x 10 T winch with cap. for 235 m of ø 56 mm chain

Mooring winches
Aft:
3 x 10/5 T winches with cap. for 220 m of ø 28 mm wire rope
2 x 30/10 T winches with cap. for 1000 m of ø 50 mm wire rope
Forward:
3 x 10/5 T winches with cap. for 220 m of ø 28 mm wire rope
2 x 30/10 T winches with cap. for 1000 m of ø 50 mm wire rope

Lift capacity
See diagram

Smit International
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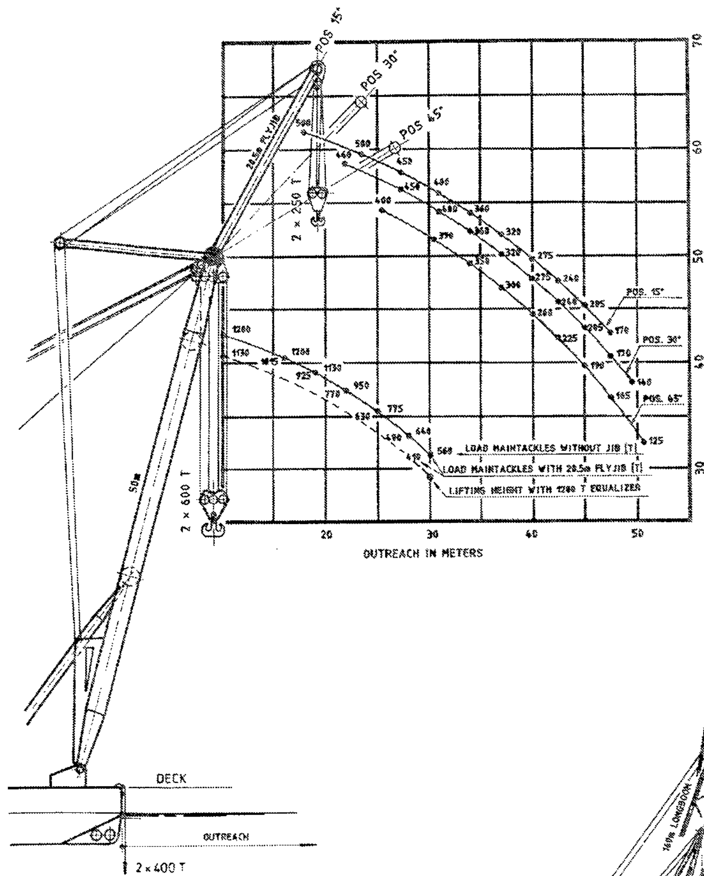
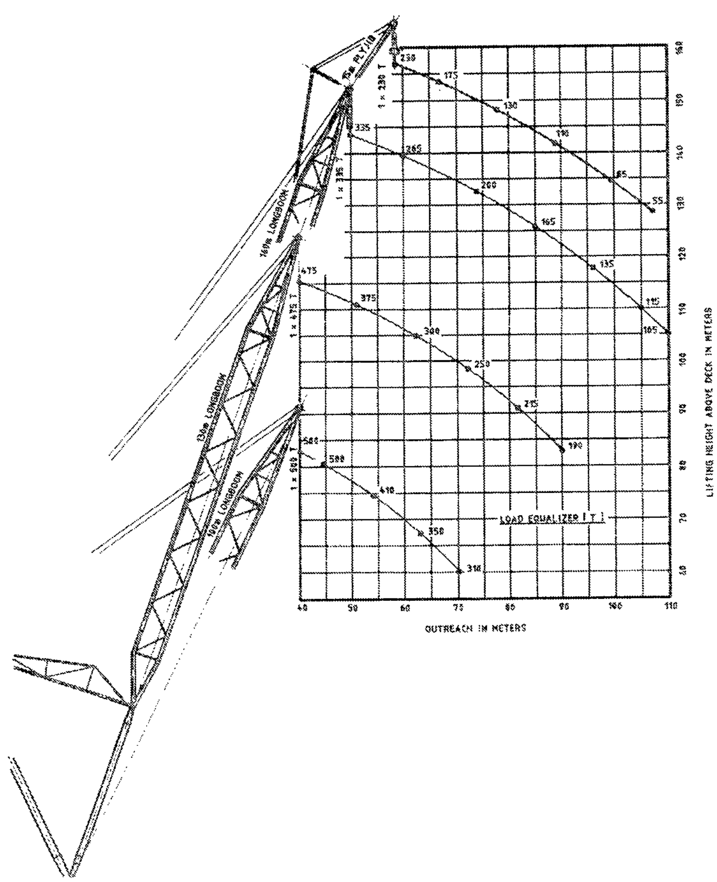
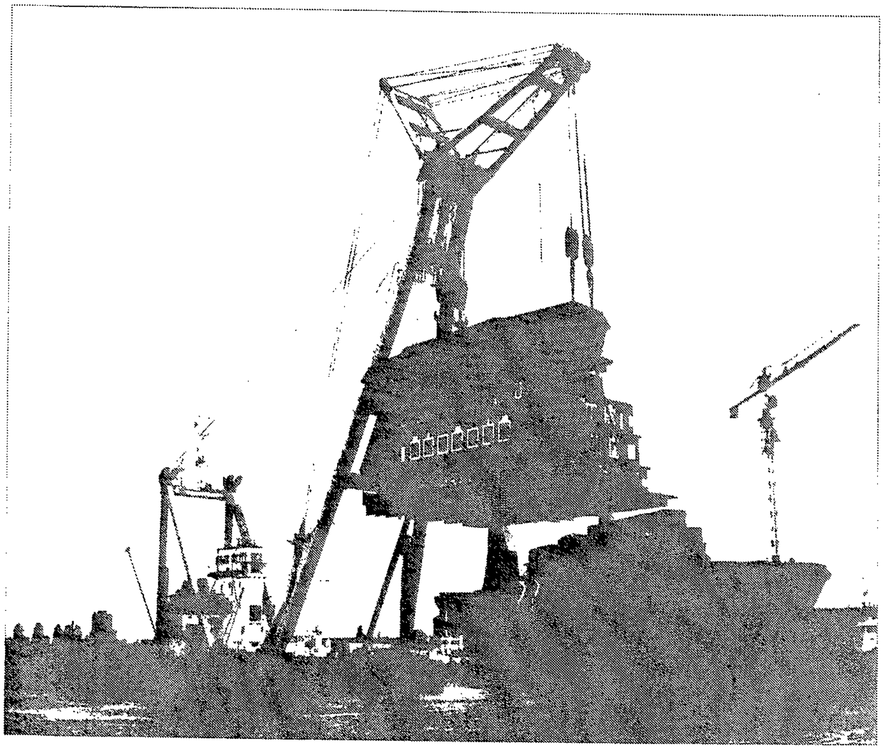
P.O. Box 1042, 3000 BA Rotterdam
The Netherlands

Main sheerlegs and flyjib tackles can operate simultaneously.
Load capacity on request.





TAKLIFT 7
SEAGOING FLOATING SHEERLEGS
1200/1600 TONNES LIFTING CAPACITY



Call sign
C6LA4

Classification
GL ✢ 100 A4 MC

Year of Construction
1976

Dimensions

Length o.a.	72.56 m
Beam	30.50 m
Depth	5.50 m
Draught	2.50 m
Sailing height at sea	40.00 m
Sailing height inland	40.00 m
Gross tonnage	3513 R.T.
Nett tonnage	2048 R.T.

Accommodation
34 persons

Propulsion
3 x 460 kW

Anchor winches
Aft:
1 x 10 T winch with cap. for 235 m of ø 56 mm chain

Mooring winches
Aft:
2 x 10/5 T winches with cap. for 220 m of ø 28 mm wire rope
2 x 30/10 T winches with cap. for 1000 m of ø 50 mm wire rope
Forward:
4 x 10/5 T winches with cap. for 220 m of ø 28 mm wire rope
2 x 30/10 T winches with cap. for 1000 m of ø 50 mm wire rope

Lift capacity
See diagram

Smit International
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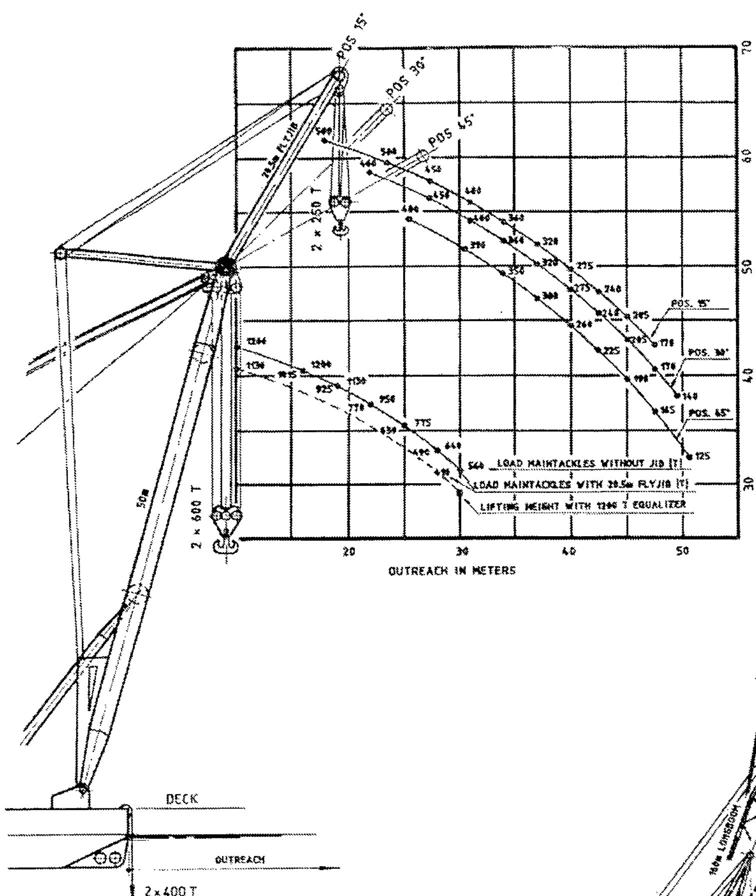
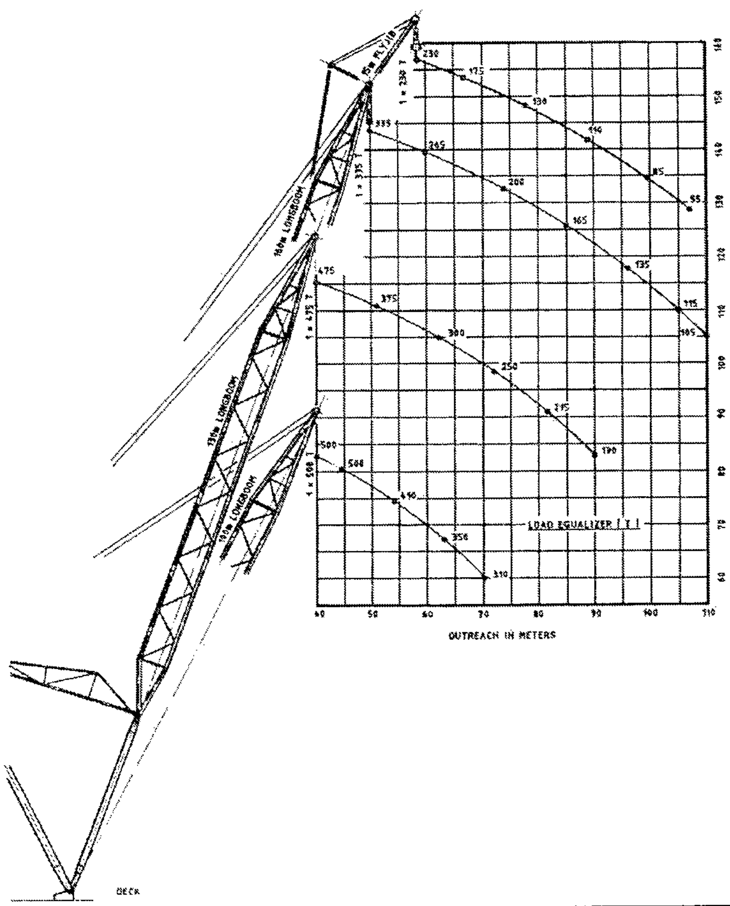
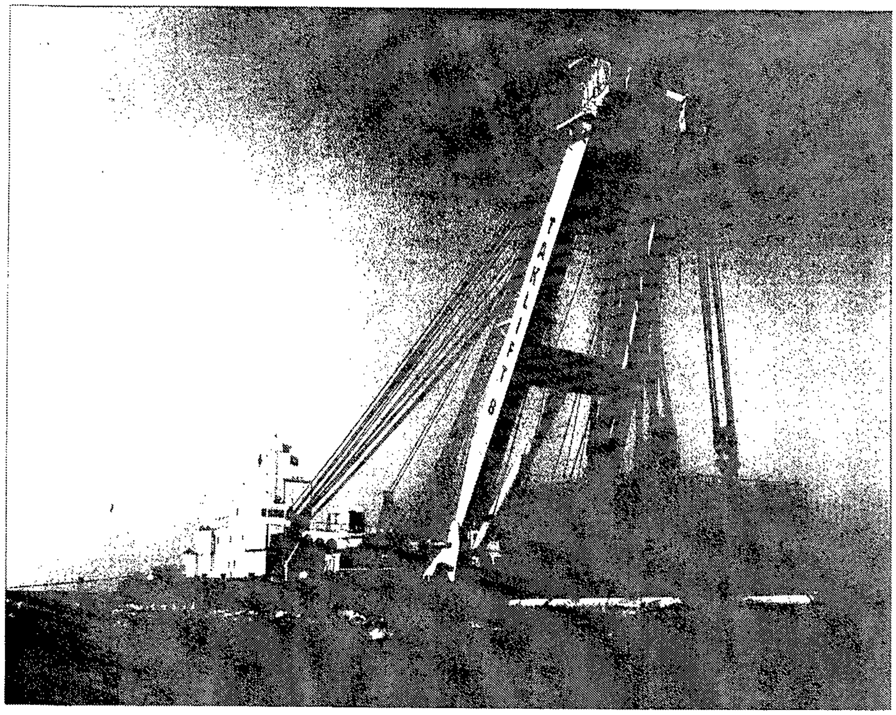
P.O. Box 1042, 3000 BA Rotterdam
The Netherlands

Main sheerlegs and flyjib tackles can operate simultaneously.
Load capacity on request.





TAKLIFT 8
SEAGOING FLOATING SHEERLEGS
3000 TONNES LIFTING CAPACITY
600 TONNES PULLING CAPACITY



Call sign
PHWG

Classification
Lloyds ✠ 100 A 1 LA

Year of Construction
1985
1993 converted to sheerlegs

Dimensions

Length o.a.	91.85 m
Beam	30.48 m
Depth	7.62 m
Draught extreme	6.16 m
Sailing height	43.50 m
Gross tonnage	5688 R.T.
Nett tonnage	1706 R.T.

Accommodation
26 persons

Lift capacity
Present capacity:
3000 T at 15.0 m outreach divided over 4 blocks of 800 T each

Mooring winches
2 x 40 T winches with cap. for 1500 m of ø 44 mm wire rope
4 x 35 T winches with cap. for 1500 m of ø 44 mm wire rope

Mooring anchors
Delta Flipper, 4 T

Pull capacity
600 T single divided over 4 wires of ø 68 mm
Pulling capacity can be increased on request

Pull winches
4 x 150 T winches with cap. for 4900 m of ø 68 mm wire rope
Max. line speed 0-10 m/min. by 150 T
Max. line speed 0-23 m/min. by 35 T
Pull force per winch at stall is 180 T

Pull anchors
Stevpris type 9 T, high holding power

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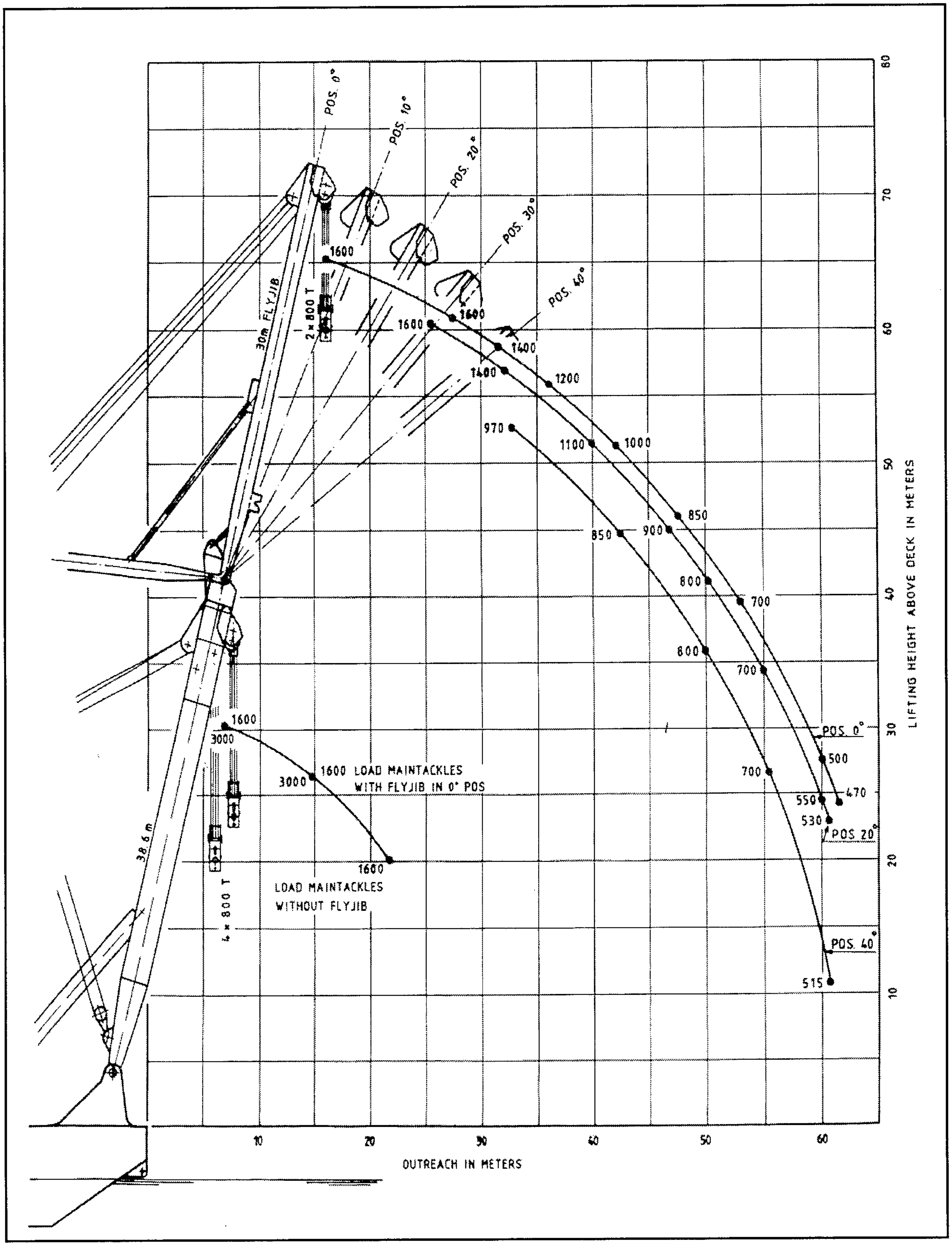
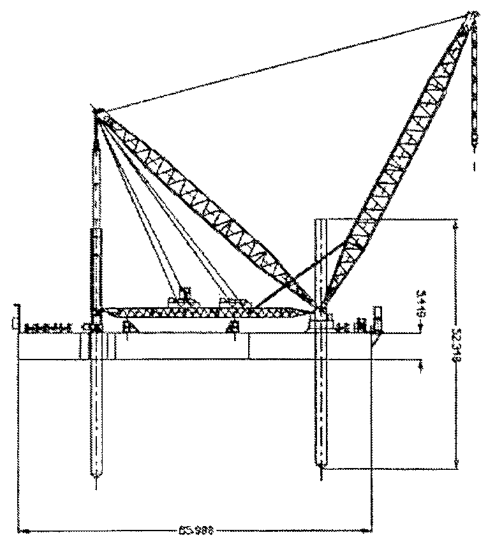
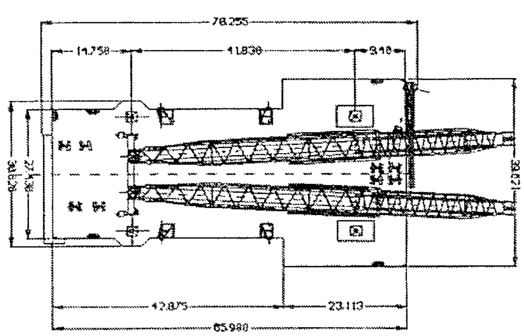
The Netherlands


POS. 0°
POS. 10°
POS. 20°
POS. 30°
POS. 40°
30m FLYJIB
2 x 800 T
1600
1600
1600
1400
1400
1200
970
1100
1000
850
850
900
800
700
800
700
700
POS. 0°
500
470
550
530
POS. 20°
POS. 40°
515
1600
3000
3000
1600 LOAD MAINTACKLES
WITH FLYJIB IN 0° POS
1600
LOAD MAINTACKLES
WITHOUT FLYJIB
4 x 800 T
38.6 m
10
20
30
40
50
60
OUTREACH IN METERS
10
20
30
40
50
60
70
80
LIFTING HEIGHT ABOVE DECK IN METERS

Appendix D
Technical Data and Cost Estimates on Jack-up Crane Barges





Appendix D

Cost Analysis, Purchasing a Jack-up barge with twin LTL-1500 cranes (1 years, 100% usage)

Contract Time Period	1	years
Months of true operation	12	months per year
Cost of capital (interest rate)	8.0	percent
Sales Tax Rate	7.5	percent
Crane Depreciation, total	5	percent (depreciation on lift cranes is low, they may appreciate)
Barge Depreciation, total	40	percent (Low Depreciation, barge purchased used)
No. of truck loads to move cranes	20	per crane (there is no counterweight - just boom, mast, and crane)
No. of shifts to Mob or Demob crane	6	per crane

Cost to Purchase Lisa A and lease 2 each LTL-1500 Transi-Lift Cranes

Purchase cost of Crane and Boom # 1 =	$	8,500,000	(quote from Lampson)
Purchase cost of Crane and Boom # 2 =	$	8,500,000	(quote from Lampson)
Purchase of Jack-up Barge (Lisa A) =	$	5,000,000	(estimate from Lampson)
Total Purchase Cost =	$	22,000,000	
Cost of Capital for duration of lift crane use	$	1,760,000	
Sales Tax on purchase	$	1,650,000	
Depreciation expense for both cranes	$	850,000	
Depreciation expense on jack-up barge	$	2,000,000	
Equipment Ownership Cost =	*$*	*6,260,000*	

Cost to Mobilize and De-Mobilize Crane Once

Cost to Transport Crane to Site	$	-	(included in purchase cost)
Cost to Transport Crane from Site	$	64,000.00	(16 hrs trucking per load x $100/hour trucking cost)
Cost to deliver barge to site	$	75,000.00	(say tug for 1 week at $10,000 per shift, plus $25,000 general expenses)
Cost to deliver barge from site	$	75,000.00	(say tug for 1 week at $10,000 per shift, plus $25,000 general expenses)
Cost to assemble Crane on site	$	90,000.00	(assume $7,500/shift to assemble crane - includes cost of 4100 helper crane)
Cost to dis-assemble Crane on site	$	90,000.00	(assume $7,500/shift to assemble crane - includes cost of 4100 helper crane)
Remove and Re-install jack-up legs on Lisa A	$	450,000.00	
Mobilization/Demob Cost =	*$*	*844,000.00*	

Cost to Operate Cranes (there are two)

Operators	2	each x	3,840	hrs =	$	161,280	(Avg hrly labor cost is $42/hour)
Oilers	2	each x	3,840	hrs =	$	122,880	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	5	each x	9,600	hrs =	$	307,200	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1	each x	1,920	hrs =	$	115,200	(assume $20/hour fuel, oil, and grease pluse $40/hour in parts and mechanic time)
Operating Cost =					*$*	*706,560*	

Equipment Rental Cost =	$	6,260,000	
Mobilization/Demob Cost =	$	844,000	(cost is 1 mob and demob since the crane is purchased and remains on job)
Operating Costs =	$	706,560	
Total Crane Costs =	$	7,810,560	

Appendix D

Cost Analysis, Purchasing a Jack-up barge with twin LTL-1500 cranes (2 years, 50% usage)

Contract Time Period	2	years
Months of true operation	6	months per year
Cost of capital (interest rate)	8.0	percent
Sales Tax Rate	7.5	percent
Crane Depreciation, total	5	percent (depreciation on lift cranes is low, they may appreciate)
Barge Depreciation, total	40	percent (Low Depreciation, barge purchased used)
No. of truck loads to move cranes	20	per crane (there is no counterweight - just boom, mast, and crane)
No. of shifts to Mob or Demob crane	6	per crane

Cost to Purchase Lisa A and lease 2 each LTL-1500 Transi-Lift Cranes

Purchase cost of Crane and Boom # 1 =	$	8,500,000	(quote from Lampson)
Purchase cost of Crane and Boom # 2 =	$	8,500,000	(quote from Lampson)
Purchase of Jack-up Barge (Lisa A) =	$	5,000,000	(estimate from Lampson)
Total Purchase Cost =	$	22,000,000	
Cost of Capital for duration of lift crane use	$	3,660,800	
Sales Tax on purchase	$	1,650,000	
Depreciation expense for both cranes	$	850,000	
Depreciation expense on jack-up barge	$	2,000,000	
Equipment Ownership Cost =	*$*	*8,160,800*	

Cost to Mobilize and De-Mobilize Crane Once

Cost to Transport Crane to Site	$	-	(included in purchase cost)
Cost to Transport Crane from Site	$	64,000.00	(16 hrs trucking per load x $100/hour trucking cost)
Cost to deliver barge to site	$	75,000.00	(say tug for 1 week at $10,000 per shift, plus $25,000 general expenses)
Cost to deliver barge from site	$	75,000.00	(say tug for 1 week at $10,000 per shift, plus $25,000 general expenses)
Cost to assemble Crane on site	$	90,000.00	(assume $7,500/shift to assemble crane - includes cost of 4100 helper crane)
Cost to dis-assemble Crane on site	$	90,000.00	(assume $7,500/shift to assemble crane - includes cost of 4100 helper crane)
Remove and Re-install jack-up legs on Lisa A	$	450,000.00	
Mobilization/Demob Cost =	*$*	*844,000.00*	

Cost to Operate Cranes (there are two)

Operators	2	each x	3,840	hrs =	$	161,280	(Avg hrly labor cost is $42/hour)
Oilers	2	each x	3,840	hrs =	$	122,880	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	5	each x	9,600	hrs =	$	307,200	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1	each x	1,920	hrs =	$	115,200	(assume $20/hour fuel, oil, and grease pluse $40/hour in parts and mechanic time)
Operating Cost =					*$*	*706,560*	

Equipment Rental Cost =	$	8,160,800	
Mobilization/Demob Cost =	$	844,000	(cost is 1 mob and demob since the crane is purchased and remains on job)
Operating Costs =	$	706,560	
Total Crane Costs =	$	9,711,360	

Appendix D

Cost Analysis, Purchasing a Jack-up barge with twin LTL-1500 cranes (3 years, 50% usage)

Contract Time Period	3	years
Months of true operation	6	months per year
Cost of capital (interest rate)	8.0	percent
Sales Tax Rate	7.5	percent
Crane Depreciation, total	5	percent (depreciation on lift cranes is low, they may appreciate)
Barge Depreciation, total	40	percent (Low Depreciation, barge purchased used)
No. of truck loads to move cranes	20	per crane (there is no counterweight - just boom, mast, and crane)
No. of shifts to Mob or Demob crane	6	per crane

Cost to Purchase Lisa A and lease 2 each LTL-1500 Transi-Lift Cranes

Purchase cost of Crane and Boom # 1 =	$	8,500,000	(quote from Lampson)
Purchase cost of Crane and Boom # 2 =	$	8,500,000	(quote from Lampson)
Purchase of Jack-up Barge (Lisa A) =	$	5,000,000	(estimate from Lampson)
Total Purchase Cost =	$	22,000,000	
Cost of Capital for duration of lift crane use	$	5,713,664	
Sales Tax on purchase	$	1,650,000	
Depreciation expense for both cranes	$	850,000	
Depreciation expense on jack-up barge	$	2,000,000	
Equipment Ownership Cost =	*$*	*10,213,664*	

Cost to Mobilize and De-Mobilize Crane Once

Cost to Transport Crane to Site	$	-	(included in purchase cost)
Cost to Transport Crane from Site	$	64,000.00	(16 hrs trucking per load x $100/hour trucking cost)
Cost to deliver barge to site	$	75,000.00	(say tug for 1 week at $10,000 per shift, plus $25,000 general expenses)
Cost to deliver barge from site	$	75,000.00	(say tug for 1 week at $10,000 per shift, plus $25,000 general expenses)
Cost to assemble Crane on site	$	90,000.00	(assume $7,500/shift to assemble crane - includes cost of 4100 helper crane)
Cost to dis-assemble Crane on site	$	90,000.00	(assume $7,500/shift to assemble crane - includes cost of 4100 helper crane)
Remove and Re-install jack-up legs on Lisa A	$	450,000.00	
Mobilization/Demob Cost =	*$*	*844,000.00*	

Cost to Operate Cranes (there are two)

Operators	2	each x	5,760	hrs =	$	241,920	(Avg hrly labor cost is $42/hour)
Oilers	2	each x	5,760	hrs =	$	184,320	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	5	each x	14,400	hrs =	$	460,800	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1	each x	2,880	hrs =	$	172,800	(assume $20/hour fuel, oil, and grease pluse $40/hour in parts and mechanic time)
Operating Cost =					*$*	*1,059,840*	

Equipment Rental Cost =	$	10,213,664	
Mobilization/Demob Cost =	$	844,000	(cost is 1 mob and demob since the crane is purchased and remains on job)
Operating Costs =	$	1,059,840	
Total Crane Costs =	$	12,117,504	

Appendix D

Cost Analysis, Leasing Jack-up barge with twin LTL-1500 cranes (1 Year, 50% Usage)

Contract Time Period	1.0	years
Months of true operation	12.00	months per year (a minimum 6 month rental period)
Number of Mobilziations/De-mobs	1.0	each
Cost of capital (interest rate)	8.0	percent
Sales Tax Rate	7.5	percent
Barge Depreciation, total	40	percent (Low Depreciation, barge purchased used)
No. of truck loads to move crane	20.0	per crane (there is no counterweight - just boom, mast, and crane)
No. of shifts to Mob or Demob crane	6.0	per crane

Cost to Rent/Lease Crane

Lease Price for LTL-1500 = $ 220,000 per month per crane (full price quote from Lampson)			
Lease Price for LTL-1500 = $ 110,000 per month per crane standby (quote from Lampson)			
Rental Cost of Crane #1 and #2 (full charge per month)	$	5,280,000	
Sales Tax on rent	$	396,000	
Subtotal, crane cost =	$	5,676,000	

Cost to Buy Lisa A and Salvage

Cost of Capital for duration of lift crane use	$	400,000	(based on $ 5,000,000 purchase cost of Lisa A Jackup Barge)
Sales Tax on purchase	$	375,000	
Depreciation (Purchase less Salvage Value)	$	2,000,000	
Subtotal, barge cost =	$	2,775,000	
Equipment Ownership Cost =	*$*	*8,451,000*	

Cost to Mobilize and De-Mobilize Crane Once

Cost to Transport Crane to Site (cost for 2 cranes)	$	64,000	(16 hrs trucking per load x $100/hour trucking cost)
Cost to Transport Crane from Site (cost for 2 cranes)	$	64,000	(16 hrs trucking per load x $100/hour trucking cost)
Cost to assemble Crane on site	$	90,000	($7,500/shift to assemble crane - includes cost of 4100 helper crane)
Cost to dis-assemble Crane on site	$	90,000	($7,500/shift to assemble crane - includes cost of 4100 helper crane)
Cost to deliver barge to site	$	75,000	(tug for 1 week at $10,000 per shift, plus $25,000 general expenses)
Cost to deliver barge from site	$	75,000	(tug for 1 week at $10,000 per shift, plus $25,000 general expenses)
Remove and Re-install jack-up legs, update Lisa A	$	450,000	
Mobilization/Demob Cost =	*$*	*908,000*	

Cost to Operate Crane

Operators	2 each x	3,840	hrs =	$	161,280	(Avg hrly labor cost is $42/hour)
Oilers	2 each x	3,840	hrs =	$	122,880	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	5 each x	9.600	hrs =	$	307,200	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, maintenace	1 each x	1,920	hrs =	$	76,800	($20/hour fuel, oil, $20/hr for barge maint. Lessor pays crane repairs)
Mobilization/Demob Cost =				$	668,160	

Equipment Rental Cost =	$	8,451,000	
Mobilization & De-mobilization =	$	908,000	(cost is for 1 mobs and demobs for cranes - barge is bought)
Operating Costs =	$	668,160	
Total Crane Costs =	$	10,027,160	

Appendix D

Cost Analysis, Leasing Jack-up barge with twin LTL-1500 cranes (2 Years, 50% Usage)

Contract Time Period	2.0	years
Months of true operation	6.00	months per year (a minimum 6 month rental period)
Number of Mobilziations/De-mobs	2.0	each
Cost of capital (interest rate)	8.0	percent
Sales Tax Rate	7.5	percent
Barge Depreciation, total	40	percent (Low Depreciation, barge purchased used)
No. of truck loads to move crane	20.0	per crane (there is no counterweight - just boom, mast, and crane)
No. of shifts to Mob or Demob crane	6.0	per crane

Cost to Rent/Lease Crane				
Lease Price for LTL-1500 =	$ 220,000 per month per crane (full price quote from Lampson)			
Lease Price for LTL-1500 =	$ 110,000 per month per crane standby (quote from Lampson)			
Rental Cost of Crane #1 and #2 (full charge per month)		$	5,280,000	
Sales Tax on rent		$	396,000	
Subtotal, crane cost =		$	5,676,000	
Cost to Buy Lisa A and Salvage				
Cost of Capital for duration of lift crane use		$	832,000	(based on $ 5,000,000 purchase cost of Lisa A Jackup Barge)
Sales Tax on purchase		$	375,000	
Depreciation (Purchase less Salvage Value)		$	2,000,000	
Subtotal, barge cost =		$	3,207,000	
Equipment Ownership Cost =		*$*	*8,883,000*	

Cost to Mobilize and De-Mobilize Crane Once				
Cost to Transport Crane to Site (cost for 2 cranes)		$	64,000	(16 hrs trucking per load x $100/hour trucking cost)
Cost to Transport Crane from Site (cost for 2 cranes)		$	64,000	(16 hrs trucking per load x $100/hour trucking cost)
Cost to assemble Crane on site		$	90,000	($7,500/shift to assemble crane - includes cost of 4100 helper crane)
Cost to dis-assemble Crane on site		$	90,000	($7,500/shift to assemble crane - includes cost of 4100 helper crane)
Cost to deliver barge to site		$	75,000	(tug for 1 week at $10,000 per shift, plus $25,000 general expenses)
Cost to deliver barge from site		$	75,000	(tug for 1 week at $10,000 per shift, plus $25,000 general expenses)
Remove and Re-install jack-up legs, update Lisa A		$	450,000	
Mobilization/Demob Cost =		*$*	*908,000*	

Cost to Operate Crane					
Operators	2 each x	3,840 hrs =	$	161,280	(Avg hrly labor cost is $42/hour)
Oilers	2 each x	3,840 hrs =	$	122,880	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	5 each x	9,600 hrs =	$	307,200	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, maintenace	1 each x	1,920 hrs =	$	76,800	($20/hour fuel, oil, $20/hr for barge maint. Lessor pays crane repairs)
Mobilization/Demob Cost =			$	668,160	

Equipment Rental Cost =	$	8,883,000	
Mobilization & De-mobilization =	$	1,366,000	(cost is for 2 mobs and demobs for cranes - barge is bought)
Operating Costs =	$	668,160	
Total Crane Costs =	$	10,917,160	

Appendix D

Cost Analysis, Leasing Jack-up barge with twin LTL-1500 cranes (3 Years, 50% Usage)

Contract Time Period	3.0	years
Months of true operation	6.00	months per year (a minimum 6 month rental period)
Number of Mobilziations/De-mobs	3.0	each
Cost of capital (interest rate)	8.0	percent
Sales Tax Rate	7.5	percent
Barge Depreciation, total	40	percent (Low Depreciation, barge purchased used)
No. of truck loads to move crane	20.0	per crane (there is no counterweight - just boom, mast, and crane)
No. of shifts to Mob or Demob crane	6.0	per crane

Cost to Rent/Lease Crane

Lease Price for LTL-1500 = $ 220,000 per month per crane (full price quote from Lampson)

Lease Price for LTL-1500 = $ 110,000 per month per crane standby (quote from Lampson)

Rental Cost of Crane #1 and #2 (full charge per month)	$	7,920,000
Sales Tax on rent	$	594,000
Subtotal, crane cost =	$	8,514,000

Cost to Buy Lisa A and Salvage

Cost of Capital for duration of lift crane use	$	1,298,560	(based on $ 5,000,000 purchase cost of Lisa A Jackup Barge)
Sales Tax on purchase	$	375,000	
Depreciation (Purchase less Salvage Value)	$	2,000,000	
Subtotal, barge cost =	$	3,673,560	
Equipment Ownership Cost =	*$*	*12,187,560*	

Cost to Mobilize and De-Mobilize Crane Once

Cost to Transport Crane to Site (cost for 2 cranes)	$	64,000	(16 hrs trucking per load x $100/hour trucking cost)
Cost to Transport Crane from Site (cost for 2 cranes)	$	64,000	(16 hrs trucking per load x $100/hour trucking cost)
Cost to assemble Crane on site	$	90,000	($7,500/shift to assemble crane - includes cost of 4100 helper crane)
Cost to dis-assemble Crane on site	$	90,000	($7,500/shift to assemble crane - includes cost of 4100 helper crane)
Cost to deliver barge to site	$	75,000	(tug for 1 week at $10,000 per shift, plus $25,000 general expenses)
Cost to deliver barge from site	$	75,000	(tug for 1 week at $10,000 per shift, plus $25,000 general expenses)
Remove and Re-install jack-up legs, update Lisa A	$	450,000	
Mobilization/Demob Cost =	*$*	*908,000*	

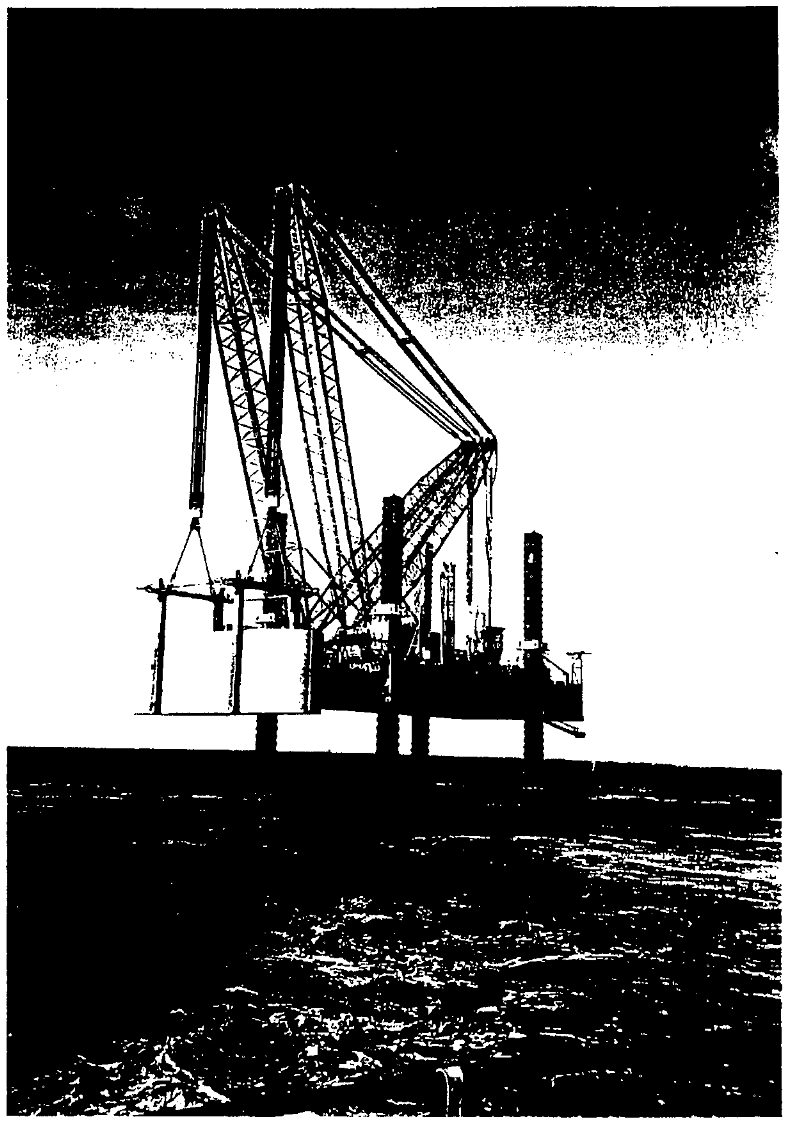
Cost to Operate Crane

Operators	2 each x	5,760 hrs =	$	241,920	(Avg hrly labor cost is $42/hour)
Oilers	2 each x	5,760 hrs =	$	184,320	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	5 each x	14,400 hrs =	$	460,800	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, maintenace	1 each x	2,880 hrs =	$	115,200	($20/hour fuel, oil, $20/hr for barge maint. Lessor pays crane repairs)
Mobilization/Demob Cost =			$	1,002,240	

Equipment Rental Cost =	$	12,187,560	
Mobilization & De-mobilization =	$	1,824,000	(cost is for 3 mobs and demobs for cranes - barge is bought)
Operating Costs =	$	1,002,240	
Total Crane Costs =	$	15,013,800	

SELF ELEVATING PLATFORM

LISA 'A'



The information given in this brochure is to be considered indicative. Lampson does not warrant or guarantee its accuracy either explicitly or implied. It is for this reason that prospective buyers shall avail themselves of the opportunity to make their own inspection prior to purchase.

LAMPSON INTERNATIONAL LTD.

CORPORATE OFFICE:
P.O. Box 6510
Kennewick, WA 99336-0502
Tel: (509) 586-0411
Fax: (509) 586-2451

BARGE SPECIFICATION

DECK

DIMENSIONS (T BOW)

Length	: 66.0m
Breadth forward	: 39.6m
Breadth aft	: 27.4m
Depth	: 5.46m

Maximum allowable load on deck is 2 tons/m^2. Maximum height of deck above sea bottom is 39.5m, in normal working is 32m

LEGS

Length	: 52.35m	Fore leg socket weight	: 3.1 t
Plan dimensions	: 2.18 x 2.18m	Dimensions of socket	: 1.49 x 1.49m
Weight	: 176 t aft / 179 t fore	Thickness	: 150mm

Ends of legs are open, legs are free flooded. Operating water depth is 34m

MOORING SYSTEM

The mooring system is used to hold LISA A when afloat. It is also used to move self elevating platform to adjacent working location. LISA A is equipped with eight hydraulic mooring winches.

.ing capacity	: 60 t max. (5th layer)	: 90 t max. (1st layer)
Holding capacity	: 170 t max. (brake on, bare drum)	: 120 t max. (5th layer)
Maximum speed	: 40 m/min (0 t load, 5th layer)	
Nominal speed	: 4 m/min (60 t load, bare drum)	

Four Jimecal winches are installed forward and four aft. Each group of four winches are powered by Jimecal Hydraulic Power Packs which are driven by Perkins diesel engines. Winches are controlled from a single panel located in the heavy lift control cabin. Each winch is equipped with a steel cable, passing through a Jimecal four roller fairlead

Length	: 600m for winches 6 & 7
	: 450m for winches 1,4,5,8
	: 350m for winches 2 & 3
Diameter	: 2 1/8" (54mm)
Breaking load	: 180 t

COMPANION GANGWAYS

Fore and aft companion gangways are fitted to provide personnel access.

Fore	: Hydraulic telescopic gangway
	: 12m closed length, 27m telescoped length
	: slews 80° forward of bow, 45° below deck
	: 3 piece bolted Aluminium construction
	: 26m total length
	: 16.5m maximum depth below deck
	: Gangway lowered and raised by means of an electric winch, mounted on gantry.

Bottom plated over houses stores, messroom and barge master's cabin, forward main electrical switchboard and ballasting system.

Steel storage container: 6m Length x 2.5m Width x 2.5m High Gross weight : 22860 kg

Portakabin	PK402	12.4m Length x 3.27m Width x 2.64m High
Barge Master's cabin	PK341	10.39m Length x 2.90m Width x 2.64m High

Main Switchboard 440 Volt installed on an intermediate flooring located forward, on starboard side.

Ballast system includes Ballast tanks, water tower, submersible pump, winch, transfer pump and ballast piping. Tank capacities: 4 No. Starboard 1650 Tons, 4 No. Port 1650 Tons, 2 Aft 1500 Tons

MAIN CHARACTERISTICS OF EQUIPMENT

SUBMERSIBLE PUMP

System	Ballast
Make	KSB
Type	UMA 250-70/22
Flow	500 m^3/hr
Head pressure	30m of water
Power	74 kW
Location	Port sponson

TRANSFER PUMP

System	Ballast
Make	Hamworthy
Type	DB250VIB3
Flow	500m^3/hr .
Head pressure	m of water
Power	36kW
Location	Forward moonpool

WATER TOWER WINCH

System	Ballast
Make	Northern Industrial Marine Ltd
Braking system	Auto fail-safe type on electric motor
Line pull	10 000 kg at mid layer
Speed	7m/min at mid layer
Cable capacity	120m (3 layers)
Electric supply	440 V, 3-phase, 60 Hz
Power	15 kW
Cable dia.	26mm
Location	Port sponson

GROUT PLANT

Location	Port side
Make	Steelfields
Cement silo	Single compartment 40 tonne capacity
Cement hopper	500 kg capacity
Colloidal mixer	Keller Colcrete SD24
Aggregates silo:	2 Compartment (2 x 32 tonne) hopper
Sand hopper	450 kg capacity 4 gate
Batch belt	500mm wide with head drive

AGITATION TANK

Location	Port side
Make	Keller Colcrete
Type	A200
Capacity	2000 litres
Drive motor	4 kW, 415 V

GENERAL PURPOSE CRANE

Location	: Port side aft
Make	: Palfinger
Type	: PS 30000 LM
Capacity	: 5000 kg
Max. Radius	: 6.0m
	: Wylie weighload 250
	: Billy Pugh

AFT GANGWAY WINCH

Make	: Super Line
Model	: SF - J
Power	: 5.5 kW

WELDING SET

Make	: Lincoln
Type	: DC400

STEAM CLEANER

Make	: Karcher
Type	: HDS 750

SANITARY FACILITY

Location	: Starboard side
Make	: Portaloo
Model	: 50 (2 WC, 2 Urinals, 2 WHB)
Dimensions	: 2.8m x 2.3m

FRESHWATER STORAGE TANK

Location	: Above Portaloo
Capacity	: 750 gallon

WATER STORAGE TANK

Location	: Starboard side
Capacity	: 10340 gallons
Length	: 10m

FUEL TRANSFER PUMP

Make	: Lincoln
Serial No.	: 158079
Speed	: 1155 rpm

DIESEL STORAGE TANKS

Location	: Port side
Bottom tank	: 2.44m x 1.8m x 1.7m
Capacity	: 1600 gallons
Top tank	: 2.46m x 1.5m x 1.2m
Capacity	: 1000 gallons

FIRE EQUIPMENT

1 Large foam extinguisher
4 Foam extinguisher's
1 Fire blanket
8 CO2 extinguisher's
1 Breathing apparatus set
1 Smoke helmet
1 Fire axe

LIFE SAVING APPLIANCES

8 Lifebuoy's
2 Life raft's - 16 man
1 Flare pack
2 Line throwing sets
1 Set of lifejackets

COMMUNICATION SYSTEM'S

1 No. VHF base station
1 No. UHF base station
1 No. VHF hand portable
3 No. UHF hand portables
Battery charger unit

ELECTRICAL SYSTEM

Onboard LISA A electric power is provided by two generators .

Location	: Port side, close to fuel tanks	Submersible pump of water tower
Make	: P.G. & M Ltd	Ballast transfer pump
Type	: MPK 300 RM	Winch of water tower
Power	: 375 kVA	Newly installed lighting and navigation lights
Voltage	: 440 Volt, 3 phase A.C. , 60Hz	

HYDRAULIC UNIT OF JACKING SYSTEM

These engines are the prime movers for the main hydraulic pumps

Location	: Pump room
Engines	: Two
Make	: Caterpillar
Model	: D346
Cylinders	: 8 No.
Brake power	: 415 HP @ 1800 rpm

HYDRAULIC OIL TANK

Location	: Pump room
Capacity	: 1900 gallons ($7.2m^3$)

DIESEL STORAGE TANK

Location	: Pump room
Capacity	: 670 gallons

TRANSILIFT CRANES

Crane A

Make	: Lampson
Model	: LTL 1500
Manufactured	: September 1992

2 DRUM WINCH UNIT:

Make	: Skagit
Model	: MD - 97 - 5D

3 DRUM WINCH UNIT:

Make	: Skagit
Model	: MD - 97 - 3D

Main Boom	: 220' Series III A
Mast	: 190' Series III A
Stinger	: 138'
Load Block	: 1500 TON

Crane B

Make	: Lampson
Model	: LTL 1500
Manufactured	: September 1992

2 DRUM WINCH UNIT:

Make	: Skagit
Model	: MD - 97 - 4M

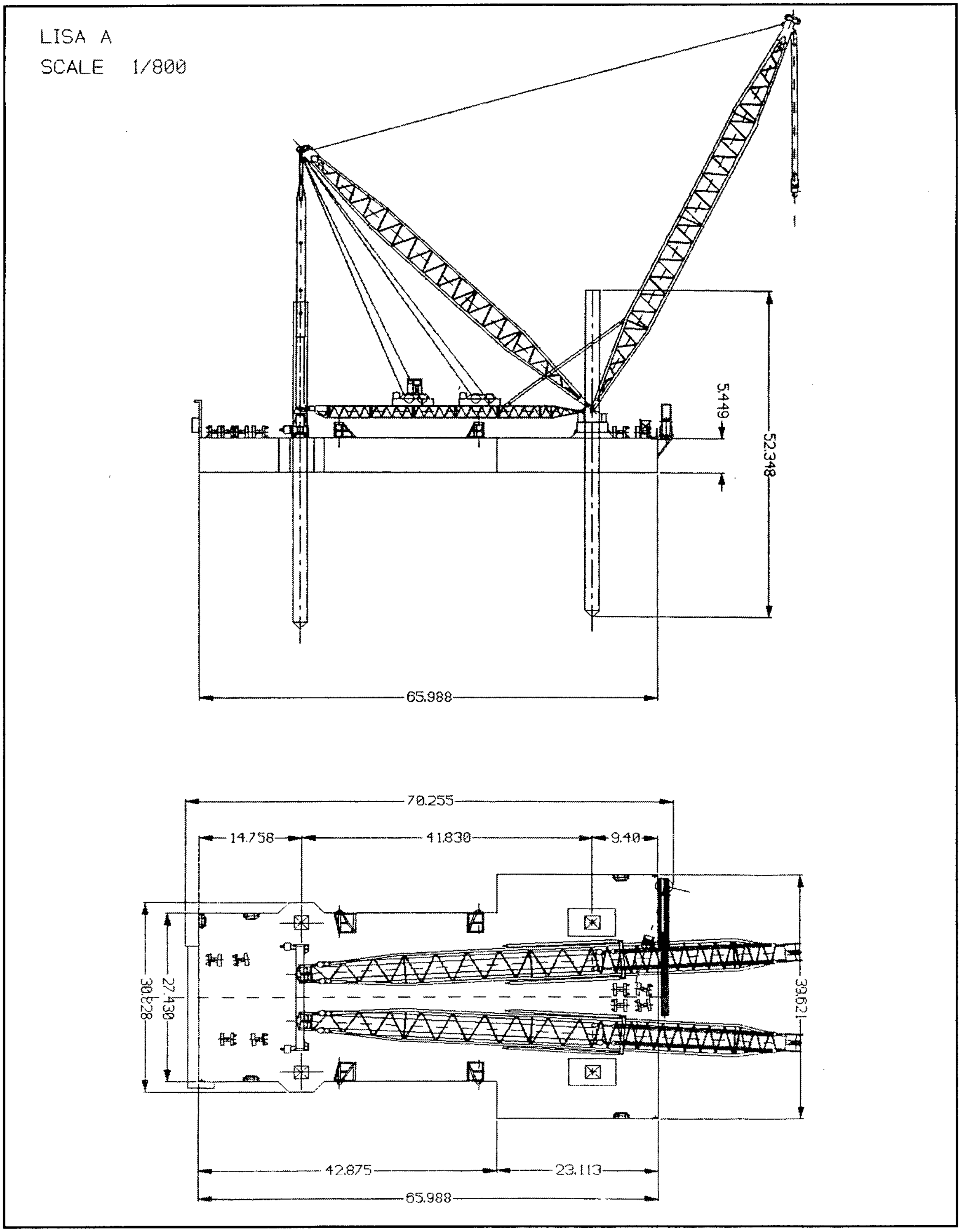
3 DRUM WINCH UNIT:

Make	: Lampson
Model	: NFL 97

MAIN BOOM CAPACITIES TYPICAL - TANDEM LIFTING

The loads quoted include the weight of the lifting frame, hoist rope reeved 50 falls and load blocks

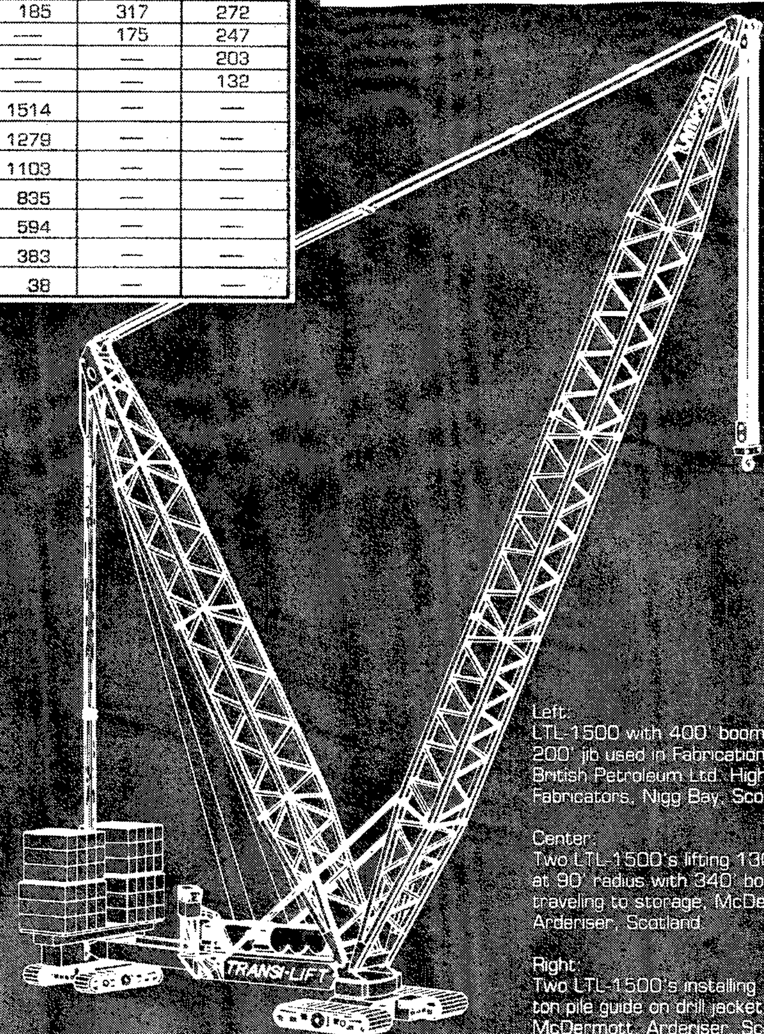
LIFT RADIUS (M)	SWL (TONNES)	LIFT RADIUS (M)	SWL (TONNES)
20	2520	25	2139
30	1755	35	1481
40	1274	45	1114
50	985	55	880


LISA A
SCALE 1/800
5.449
52.348
65.988
70.255
14.758
41.830
9.40
30.628
27.430
39.621
42.875
23.113
65.988

Boom Length Feet	Mast Length Feet	Load Radius Feet	Capacities - Kips			
			Main Boom		Jib 15 Degree Offset	
			80 Ft. Stinger	120 Ft. Stinger	80 Feet	200 Feet
280	220	51	2610	2550	—	—
		100	2352	2298	—	—
		150	1634	2031	—	—
		200	1162	1627	—	—
		250	768	1062	—	—
		280	529	596	—	—
340	220	62	2287	2307	—	—
		100	2150	2152	675	—
		150	1606	1938	602	—
		200	1137	1614	549	—
		300	632	904	427	—
		340	393	473	393	—
400	220	72	1871	1955	—	—
		100	1754	1856	684	—
		150	1133	1616	623	407
		200	773	1295	571	388
		300	418	729	466	341
		400	192	185	317	272
		450	—	—	175	247
		500	—	—	—	203
		550	—	—	—	132
430	220	78	—	1514	—	—
		150	—	1279	—	—
		200	—	1103	—	—
		250	—	835	—	—
		300	—	594	—	—
		350	—	383	—	—
		430	—	38	—	—

Neil F. Lampson Inc.

TRANSI-LIFT® SERIES III
Model LTL-1500



Left:
LTL-1500 with 400' boom and 200' jib used in Fabrication of British Petroleum Ltd. Highland Fabricators, Nigg Bay, Scotland.

Center:
Two LTL-1500's lifting 1300 tons at 90' radius with 340' boom traveling to storage, McDermott, Ardersier, Scotland.

Right:
Two LTL-1500's installing 1300 ton pile guide on drill jacket, McDermott, Ardersier, Scotland.

Cover:
Two LTL-1500's installing module on Tension Leg Platform, McDermott, Ardersier, Scotland.

— PRELIMINARY —

LTL 1500 TRANSI-LIFT SERIES 3A/BARGE MOUNT; LAING/GTM

220 FT BOOM 190 FT MAST 138 FT STINGER
44 MPH Wind - BSI CODES - 34/16 PT BM HST - REV 5; 6/26/92

APPLICABLE CONDITIONS:

1.) Weight of loadfalls, load block, hook weightball, slings, etc. are part of the lifted load.
2.) Machine shall be level to within plus or minus 3/4 inch in 30'-0.
3.) Barge deck must be firm and able to support local forces developed by the machine.
4.) Capacities are based on structural strength of machine components and on machine/barge attachments.
5.) Capacities shown INCLUDE strength of mainfall cable & No. parts.
6.) Gravity center of suspended load shall be maintained coincident with the plane of the boom and mast centerlines.
7.) Consult Operations Manual before swinging boom past retracted barge legs.
8.) All weights shown are in units of 1000 pounds (ie KIPS).
9.) Load Block WT.(REF) = 110 KIPS.
10.) Chart Capacities do not consider effect of wind on the suspended load.
11.) LOAD RADIUS IS MEASURED FROM BOOM HEEL PIN CENTERLINE.
12.) MAINFALL CAPACITY = 2778 KIPS @ 3.5:1 WITH 50 PARTS OF 1.5 IN.DIA WIRE.(BS=125 ST).

MAIN BOOM CAPACITY - KIPS. (STATIC).

LIFT RADIUS (FEET)	BOOM ANGLE (DEGREES)	CAPACITY 0 KIPS AUX. CWT.	BOOM TIP HEIGHT ABOVE DECK (FEET)
50.0	77.6	2727.6	228.2
55.0	76.3	2680.1	227.0
60.0	75.0	2632.3	225.7
65.0	73.6	2585.8	224.2
70.0	72.2	2539.8	222.6
75.0	70.8	2396.1	220.8
80.0	69.5	2235.9	218.9
85.0	68.1	2094.5	216.9
90.0	66.6	1968.8	214.7
95.0	65.2	1856.3	212.4
100.0	63.7	1755.1	210.0
105.0	62.3	1663.4	207.3
110.0	60.8	1580.1	204.5
115.0	59.3	1504.0	201.5
120.0	57.7	1434.2	198.4
125.0	56.2	1370.0	195.0
130.0	54.6	1310.7	191.5
135.0	52.9	1255.7	187.7
140.0	51.3	1204.7	183.7
145.0	49.6	1157.2	179.5
150.0	47.8	1112.8	174.9
155.0	46.0	1071.3	170.1

16:28:58 26 Jun 1992
COMBINE+TIPPING

— PRELIMINARY —

LTL 1500 TRANSI-LIFT SERIES 3A/BARGE MOUNT; LAING/GTM
220 FT BOOM 190 FT MAST 138 FT STINGER
44 MPH Wind - BSI CODES - 34/16 PT BM HST - REV 5; 6/26/92

MAIN BOOM CAPACITY - KIPS. (STATIC).

LIFT RADIUS (FEET)	BOOM ANGLE (DEGREES)	CAPACITY 0 KIPS AUX. CWT.	BOOM TIP HEIGHT ABOVE DECK (FEET)
160.0	44.1	1032.3	165.0
165.0	42.2	995.7	159.5
170.0	40.2	961.3	153.6
175.0	38.1	928.7	147.3
180.0	35.9	898.0	140.5
185.0	33.5	868.9	133.1
190.0	31.1	841.3	124.9
195.0	28.4	815.1	115.9
200.0	25.4	790.2	105.7
205.0	22.1	766.5	93.8
210.0	18.1	743.9	79.6
215.0	13.0	722.3	60.6
220.0	.8	535.2	14.0

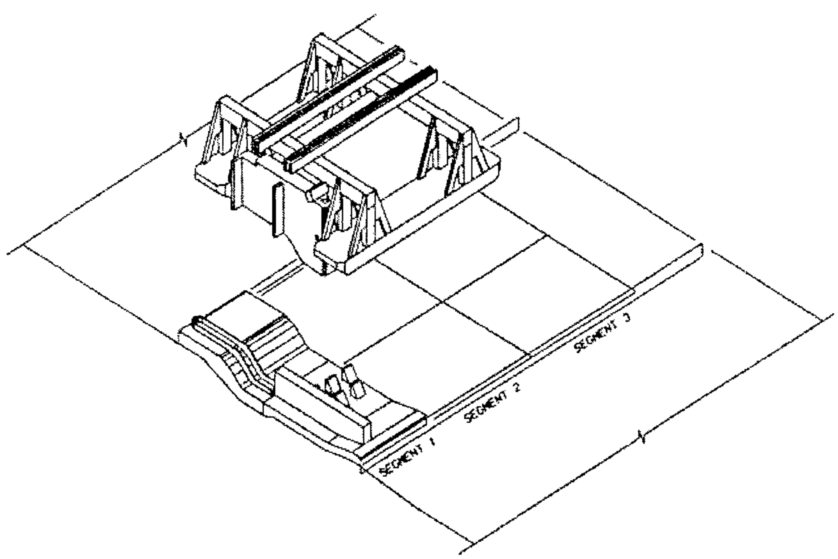
16:29:02 26 Jun 1992
COMBINE+TIPPING

Neil F. Lampson Inc.

TRANSI-LIFT®
Model LTL-2600

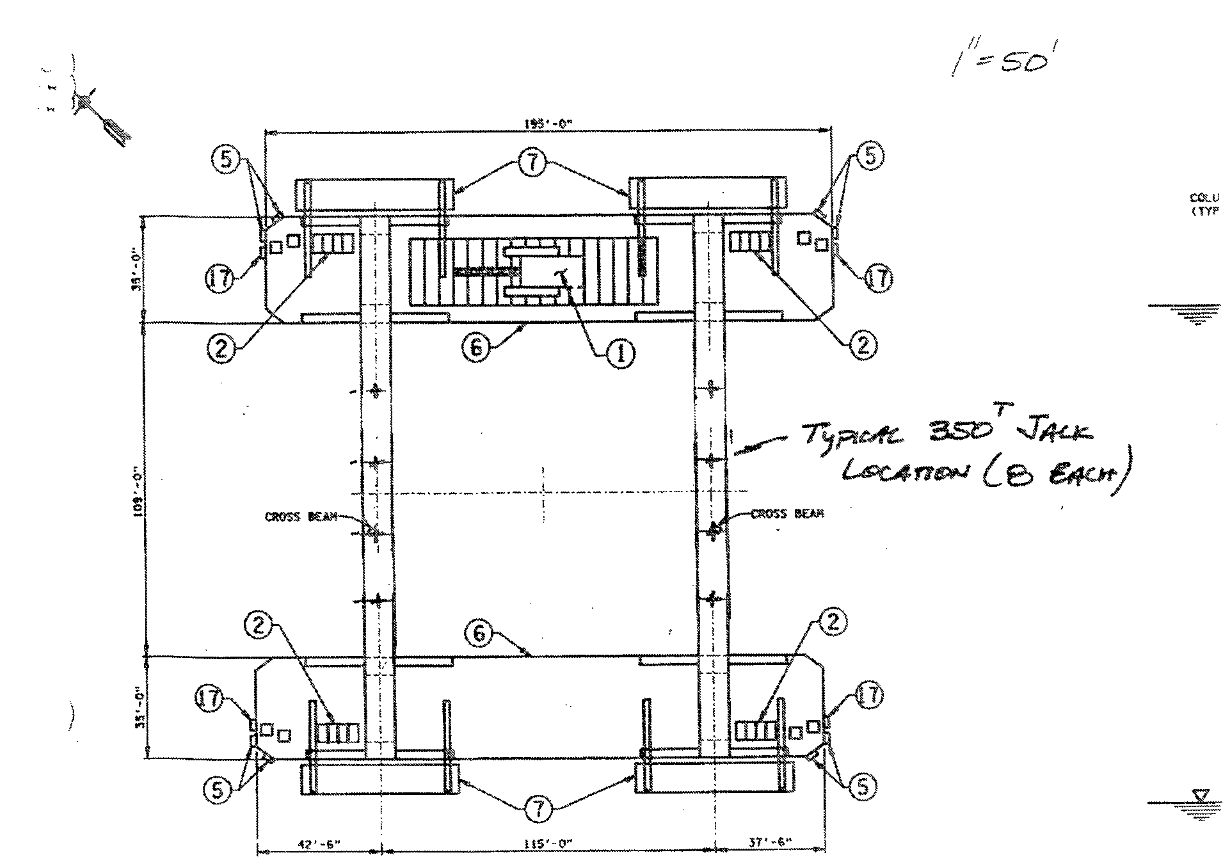
Lift Radius (feet)	Boom Angle (Degrees)	Auxiliary Counterweight Required (Kips) 3700	3600	3000	1800	Boom Tip Height (Feet)
70.0	81.0	**2751.4**	**2751.4**	**2751.4**	**2751.4**	428.1
80.0	79.6	**2707.1**	**2707.1**	**2707.1**	2589.1	426.[illegible]
90.0	78.2	**2681.1**	**2661.1**	**2661.1**	2259.9	424.[illegible]
100.0	76.8	**2613.5**	**2613.5**	**2613.5**	1996.4	421.9
110.0	75.4	**2564.6**	**2564.6**	**2564.6**	1780.8	419.3
120.0	73.9	**2515.2**	**2515.2**	**2515.2**	1600.9	416.5
130.0	72.5	**2464.4**	**2464.4**	2390.2	1448.7	413.4
140.0	71.1	**2412.9**	**2412.9**	2192.4	1318.1	410.0
150.0	69.6	**2360.8**	**2360.8**	2020.9	1204.9	406.3
160.0	68.2	**2286.7**	2253.2	1870.7	1105.7	402.3
170.0	66.7	**2137.0**	2098.1	1738.1	1018.1	398.1
180.0	65.2	**2002.2**	1960.2	1620.2	940.2	393.5
190.0	63.6	**1879.8**	1836.7	1514.6	870.4	388.6
200.0	62.1	**1768.1**	1725.5	1419.5	807.5	383.3
210.0	60.5	**1665.5**	1624.8	1333.4	750.5	377.7
220.0	59.0	**1570.8**	1533.2	1255.0	698.7	371.8
230.0	57.3	**1483.0**	1449.5	1183.4	651.3	365.4
240.0	55.7	**1401.1**	1372.8	1117.8	607.8	358.7
250.0	54.0	**1324.6**	1302.1	1057.3	567.7	351.5
260.0	52.3	**1252.6**	1236.7	1001.4	530.6	343.8
270.0	50.5	**1184.7**	1176.2	949.5	496.2	335.7
280.0	48.7	**1120.4**	1119.9	901.3	464.2	327.0
290.0	46.9	**1059.2**	**1059.2**	856.4	434.3	317.8
300.0	45.0	**1000.8**	**1000.8**	814.4	406.4	307.9
310.0	43.0	**944.7**	**944.7**	775.0	380.2	297.4
320.0	40.9	**890.8**	**890.8**	738.1	355.6	286.0
330.0	38.8	**838.5**	**838.5**	703.3	332.4	273.[illegible]
340.0	36.5	**787.6**	**787.6**	670.5	310.5	26[illegible]
350.0	34.1	**737.7**	**737.7**	639.4	289.7	246.[illegible]
360.0	31.5	**688.4**	**688.4**	610.0	270.0	230.3
370.0	28.8	**639.1**	**639.1**	582.1	251.3	212.7
380.0	25.8	**589.2**	**589.2**	555.5	233.4	192.9
390.0	22.3	**537.4**	**537.4**	530.2	216.3	169.9
400.0	18.3	**481.7**	**481.7**	**481.7**	199.9	142.1
410.0	13.1	**416.6**	**416.6**	**416.6**	183.8	105.1
420.0	.5	**284.2**	**284.2**	**284.2**	166.6	14.0

Appendix E
Technical Data and Cost Estimates on Catamaran Crane Barges with Lift Beams



*** SAFETY PAYS ***

5	4	3



PLAN - CATAMARAN BARGE

SCALE: 1"=20'

LIST OF BARGE EQUIPMENT

1. (R) MANITOWOC 3900 SERIES 2
2. (R) SKAGIT 3 DRUM WINCH (RB97)
3. (*) HYDRAULIC POWER PACK DSL
4. (*) AIR TUGGER (INGERSOL-RAND V/K4 UL)
5. STEV/FIX ANCHORS 7000 KG
6. BARGE (195' X 35' X 14')
7. SPONSON 10'X50'X13' (OPTIONAL)
8. (*) CAT GENERATOR 150 KV DSL
9. (*) AIR COMPRESSOR - JOY 1300CFM
10. (*) AIR COMPRESSOR DSL (DIVER AIR)
11. (*) DECOMPRESSION CHAMBER (PVN01)
12. (*) DECOMPRESSION CHAMBER (HP230)
13. (*) PEERLESS JET PUMP (6")
14. (*) POWER PACK FOR HOSE REELS
15. (*) HOSE REELS FOR PIN PULLERS
16. (*)HYDRAULIC POWER PACK AND HOSE REEL FOR COUPLER/WEDGE JACKS
17. LWT/DANFORTH 15T ANCHORS
18. 350 TON HYDRAULIC JACK ON SUPPORT FRAME
19. (*)COUNTERWEIGHT (TO BE USED ON GANTRY BEAM WHEN LIFTING PRECAST PIER WALL)
20. (*) FUEL
21. (*) CONTROL HOUSE
22. (*) TOOL ROOM / ENGINE ROOM

(*) THESE ITEMS ARE NOT SHOWN TO MAINTAIN CLARITY

(R) = RENTED EQUIPMENT

Check Plate Girder Spanning Between Catamaran Barges

Total Load =	**4,000**	tons
No. of Plate Girders =	4	each (2 pairs of 2 each)
No. of Jacks/beam =	4	each
Spacing Betwn Jacks =	22	feet
Req'd Load per Jack =	500	tons
Barge Width =	50.0	ft

Girder Length Overall =	160.0	feet				
Girder Depth Overall =	13.00	feet			Width	Thick.
Max Moment in single Girder =	58,000	k-ft,	59,316	k-ft provided	(feet)	(inches)
Clear Span between hulls =	110.0	feet				
Number of Webs =	3	each		Top Flange Dimensions	7.5	2.00
Number of Web Stiffeners =	9	locations		Bottom Flange Dimensions	7.5	2.00
Yield Strength of Steel =	50	ksi		Web Thickness		1.5
Web Stiffener Spacing =	55.0	ft		Web Stiffener Thickness		1.5

Weight of Single Plate Girder

Weight of Top Flange	98,000	lbs		
Weight of Bottome Flange	98,000	lbs		
Weight of all webs	372,400	lbs		
Weight of all web stiffeners	52,541	lbs		
Total Girder Weight =	620,941	lbs, or	3.88	klf

Plate Girder Properties

Top Flange Moment of Inertia =	266,865	in.^4
Bottom Flange Moment of Inertia =	266,865	in.^4
Single Web Moment of Inertia =	438,976	in.^4
Total Girder Inertia =	1,850,658	in.^4
Girder Section Mod. =	23,726	in.^3
Radius of Gyration =	20.23	in. (flange + 1/6 web) about yy axis
Max Web Stiffener spacing =	100.3	feet

Assume stiffeners sufficient to allow Fb = 0.60 Fy.

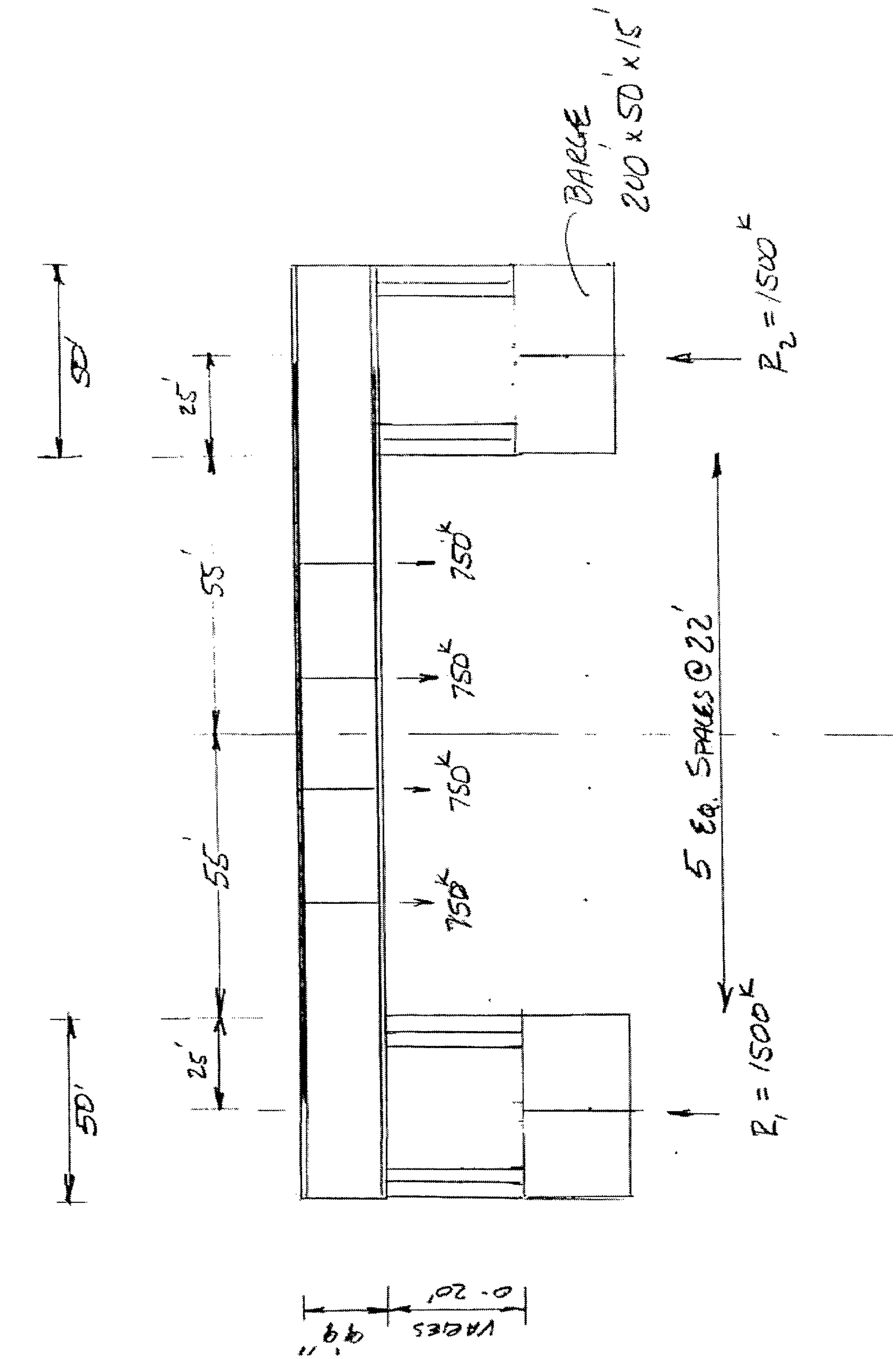
Design Moment =	58,000	kip ft
Girder Capacity as designed =	59,316	kip ft

Check Shear Stress

Allow web shear stress =	8.01	ksi
Worst Case Shear =	1,742	kips
Total Web Area =	684.0	in ^2
Fv =	2.55	ksi

Check Approximate Deflection

Clear Span =	1,320	in.
Equivalent uniform load =	3,354	psi
Assumed Value for E =	29,600	ksi
Approximate Deflection =	1.69	in.



Four–column solution (1 in. = 30 ft)

Estimate for 3,000 ton Capacity Catamaran (Lifting Beam Method)

	Quantity			Unit Price			Extension
Basic Barge and Heavy Lift Beam System							
Purchase first work barge, 200 x 50 barge (Used)	10,000	sf	at	70	$/sf	$	700,000
Purchase second work barge, 200 x 50 barge (Used)	10,000	sf	at	70	$/sf	$	700,000
Rework Barge frames to carry structural loads	2	ea	at	125,000	$/each	$	250,000
Purchase and Install 250 ton sponsons at outer column	4	ea	at	25,000	$/each	$	100,000
Fabricate Main Support Columns, 8 ea x 30' x 0.60 k/lf	144,000	lbs	at	1.750	$/lb	$	252,000
Fabricate Lateral Support Col., 8 ea x 30' x 0.30 k/lf	144,000	lbs	at	1.750	$/lb	$	252,000
Install support columns on barge	288,000	lbs	at	1.000	$/lb	$	288,000
Fabricate Lifting Girder #1, 1 ea x 210' long x 2.5 k/lf	515,000	lbs	at	1.500	$/lb	$	772,500
Fabricate Lifting Girder #2, 1 ea x 210' long x 2.5 k/lf	515,000	lbs	at	1.500	$/lb	$	772,500
Erect Lifting Girders on barges	1,030,000	lbs	at	0.250	$/lb	$	257,500
Fabricate Lateral Bracing to connect Catamarans	1	LS	at	50,000		$	50,000
Install lateral bracing system	1	LS	at	25,000		$	25,000
Fabricate Lifting Frame (attaches to structural shell)	700,000	lbs	at	1.500	$/lb	$	1,050,000
Fabricate Survey Towers, 2 each x 50' high	40,000	lbs	at	1.250	$/lb	$	50,000
Lifting System							
Purchase 350 ton Lifting Jacks and related Equip.	8	ea	at	45,000	$/each	$	360,000
Purchase related mounting plates, equipment	8	ea	at	5,000	$/each	$	40,000
Related Work							
Purchase and install electrical system	1	ea	at	550,000	$/each	$	550,000
Purchase and install mechanical system	1	ea	at	390,000	$/each	$	390,000
Cat Generator (150 kw)	2	ea	at	30,000	$/each	$	60,000
Air Compressors	2	ea	at	10,000	$/each	$	20,000
Engineering and Support Services	1	ea	at	350,000	$/each	$	350,000
Mooring Equipment							
Skagit 3 Drum Winches	4	ea	at	100,000	$/each	$	400,000
Danforth Anchors (15000 kg)	4	ea	at	30,000	$/each	$	120,000
Misc. Anchors (7000 kg)	8	ea	at	20,000	$/each	$	160,000
Hydraulic power packs and air tuggers	1	ls	at	50,000	$/each	$	50,000
Install all winches, anchors, power systems	1	LS	at	200,000		$	200,000

Initial Construction Cost =	$	8,219,500
Less Salvage Value on Hulls	$	(700,000)
Less Salvage Value on Mooring	$	(365,000)
Total Cost, net of salvage	$	7,154,500

Appendix E

Cost Analysis, 3,000 Ton Catamaran, Lift Beam Method (1 years, 100% Usage)

Contract Time Period	1.0	years
Months of true operation	12.00	months per year
Cost of capital (interest rate)	8.0	percent
Sales Tax Rate	0.0	percent (tax included in construction cost estimate)
Salvage Value of Equipment	$ 1,065,000	(see detailed estimate for salvage value)

Cost to Manufacture Catamaran Barge Complete (see detailed estimate)		
Cost of Capital for duration of lift crane use	$ 657,600	(based on purchase cost of $ 8,220,000 for all equipment)
Depreciation Expense	$ 7,155,000	
Equipment Ownership Cost =	*$ 7,812,600*	

Cost to Mobilize and De-Mobilize Crane Once		
Cost to deliver barge #1 to site	$ 75,000	(tug for 1 week at $10,000/shift, $25,000 general expenses)
Cost to deliver barge #1 from site	$ 75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Cost to deliver barge #2 to site	$ 75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Cost to deliver barge #2 from site	$ 75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Assemble and Dis-assemble components	$ 137,500	(15 shifts @ $7,500/shift. Add $25K general expenses)
Mobilization/Demob Cost =	*$ 437,500*	

Cost to Operate Cranes						
Operators	4	each x	7,680	hrs =	$ 322,560	(Avg hrly labor cost is $42/hour)
Oilers	2	each x	3,840	hrs =	$ 122,880	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	6	each x	11,520	hrs =	$ 368,640	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1	each x	1,920	hrs =	$ 67,200	($15/hr FOG plus $20/hour in parts and mechanic for each barge)
Total Operating Cost =					*$ 881,280*	

Equipment Rental Cost =	$ 7,812,600
Mobilization & De-mobilization =	$ 437,500
Operating Costs =	$ 881,280
Total Crane Costs =	$ 9,131,380

Appendix E

Cost Analysis, 3,000 Ton Catamaran, Lift Beam Method (2 years, 50% Usage)

Contract Time Period	2.0	years
Months of true operation	6.00	months per year
Cost of capital (interest rate)	8.0	percent
Sales Tax Rate	0.0	percent (tax included in construction cost estimate)
Salvage Value of Equipment	$ 1,065,000	(see detailed estimate for salvage value)

Cost to Manufacture Catamaran Barge Complete (see detailed estimate)

Cost of Capital for duration of lift crane use	$ 1,367,808	(based on purchase cost of $ 8,220,000 for all equipment)
Depreciation Expense	$ 7,155,000	
Equipment Ownership Cost =	*$ 8,522,808*	

Cost to Mobilize and De-Mobilize Crane Once

Cost to deliver barge #1 to site	$ 75,000	(tug for 1 week at $10,000/shift, $25,000 general expenses)
Cost to deliver barge #1 from site	$ 75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Cost to deliver barge #2 to site	$ 75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Cost to deliver barge #2 from site	$ 75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Assemble and Dis-assemble components	$ 137,500	(15 shifts @ $7,500/shift. Add $25K general expenses)
Mobilization/Demob Cost =	*$ 437,500*	

Cost to Operate Cranes

Operators	4 each x	7,680 hrs =	$ 322,560	(Avg hrly labor cost is $42/hour)
Oilers	2 each x	3,840 hrs =	$ 122,880	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	6 each x	11,520 hrs =	$ 368,640	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1 each x	1,920 hrs =	$ 67,200	($15/hr FOG plus $20/hour in parts and mechanic for each barge)
Total Operating Cost =			*$ 881,280*	

Equipment Rental Cost =	$ 8,522,808
Mobilization & De-mobilization =	$ 437,500
Operating Costs =	$ 881,280
Total Crane Costs =	$ 9,841,588

Appendix E

Cost Analysis, 3,000 Ton Catamaran, Lift Beam Method (3 years, 50% Usage)

Contract Time Period		3.0	years
Months of true operation		6.00	months per year
Cost of capital (interest rate)		8.0	percent
Sales Tax Rate		0.0	percent (tax included in construction cost estimate)
Salvage Value of Equipment	$	1,065,000	(see detailed estimate for salvage value)

Cost to Manufacture Catamaran Barge Complete (see detailed estimate)

Cost of Capital for duration of lift crane use	$	2,134,833	(based on purchase cost of $ 8,220,000 for all equipment)
Depreciation Expense	$	7,155,000	
Equipment Ownership Cost =	*$*	*9,289,833*	

Cost to Mobilize and De-Mobilize Crane Once

Cost to deliver barge #1 to site	$	75,000	(tug for 1 week at $10,000/shift, $25,000 general expenses)
Cost to deliver barge #1 from site	$	75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Cost to deliver barge #2 to site	$	75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Cost to deliver barge #2 from site	$	75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Assemble and Dis-assemble components	$	137,500	(15 shifts @ $7,500/shift. Add $25K general expenses)
Mobilization/Demob Cost =	*$*	*437,500*	

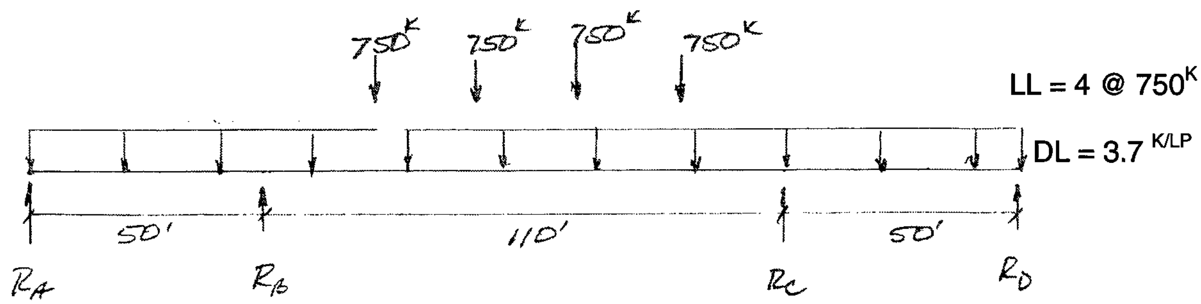
Cost to Operate Cranes

Operators	4	each x	11,520	hrs =	$	483,840	(Avg hrly labor cost is $42/hour)
Oilers	2	each x	5,760	hrs =	$	184,320	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	6	each x	17,280	hrs =	$	552,960	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1	each x	2,880	hrs =	$	100,800	($15/hr FOG plus $20/hour in parts and mechanic for each barge)
Total Operating Cost =					*$*	*1,321,920*	

Equipment Rental Cost =	$	9,289,833
Mobilization & De-mobilization =	$	437,500
Operating Costs =	$	1,321,920
Total Crane Costs =	$	11,049,253

Lift Girder

1" = 40'



Calculate Fixed End Moments (Side Spans) [4-column solution]

$$M_{AB}^{F} = -M_{BA}^{F} = M_{CD}^{F} = -M_{DC}^{F}$$

$$M_{AB}^{F} = -\frac{wl^2}{12} = \frac{3.7(50)^2}{12} = -770.8^{K1}$$

$$M_{BC}^{F} = M_{CB}^{F} = -\frac{wl^2}{12} = \frac{3.7(110)^2}{12} = -3{,}730.8^{K1}$$

Calculate Fixed End Moments (Main Span)

$$M_{BC}^{F} = \frac{Pab^2}{L^2} \qquad M_{CB}^{F} = \frac{Pa^2b}{L^2}$$

Load #	a	b	L	M_{BC}^{F}	M_{CB}^{F}
1	22'	88'	110'	-10, 560	2,640
2	44'	66'	110'	-11,880	7,920
3	66'	44'	110'	-7,920	11,880
4	88'	22'	110'	-2,640	10,560
				-33,000K1	33,000

Summarize FEM

$$M_{AB}^{F} = -M_{BA}^{F} = -770.8^{K1}$$

$$M_{BC}^{F} = -M_{CB}^{F} = -3{,}730.8 - 33{,}000 = -36{,}730.8$$

$$M_{CD}^{F} = -M_{DC}^{F} = -770.8$$

$$\text{Side Span} \rightarrow \frac{I}{L} = \frac{110}{50} = 2.2$$

$$\text{Main Span} \rightarrow \frac{I}{L} = \frac{110}{110} = 1.0$$

Moment Distribution

	1	0.688	0.312	0.312	0.688	1
FEM	-771	771	-36,731	+36,731	-771	+771
DM	+771	24,740	11,220	-11,220	-24,741	-771
COM	12,370	386	-5,610	5,610	-386	-12,741
DM	-12,370	3,594	1,630	-1,630	-3,594	+12,741
COM	1,797	-6,185	-815	815	6,185	-1,797
DM	-1,797	4,816	2,184	-2,184	-4,816	+1,797
COM	2,408	-899	-1,092	1,092	899	-2,408
DM	-2,408	1,370	621	-621	-1,370	+2,408
COM	685	-1,204	-310	310	1,204	-685
DM	-685	1,041	472	-472	-1,041	+685
COM	520	-343	-236	236	343	-520
DM	-520	398	181	-181	-398	520
COM	199	-260	-91	91	260	-199
DM	-199	242	110	-110	-242	199
COM	121	-100	-55	55	100	-121
DM	-121	107	48	-48	-107	121
COM	53	-60	-24	24	60	-53
DM	-53	57	26	-26	-57	53
COM	28	-26	-13	13	26	-28
DM	-28	27	12	-12	-27	28
	0	28,472	-28,743	+28,473	-28,472	0

NOTE: Should use Modified K.

Calculate R_A

$$M_{BA} = -28{,}472 = \frac{-50^2(3.7)}{2} + 50\,R_A$$

$$R_A = -476.9^K \text{ (Means Tension)}$$

$$R_B = R_C = 1/2\,[210\,(3.7) + 4\,(750) + 2\,(476.9)]$$

$$R_B = R_C = 2{,}365.4^K \text{ (Compression)}$$

Calculate Moment @ Midspan

$$(-)\text{ Driving Moments} = 750\,(11+33) = 33{,}000 \quad \text{LL}$$

$$\frac{3.7\,(105)^2}{2} = 20{,}396 \quad \text{DL}$$

$$476.9\,(105) = \frac{50{,}075}{-103{,}471^{K1}} \quad R_A$$

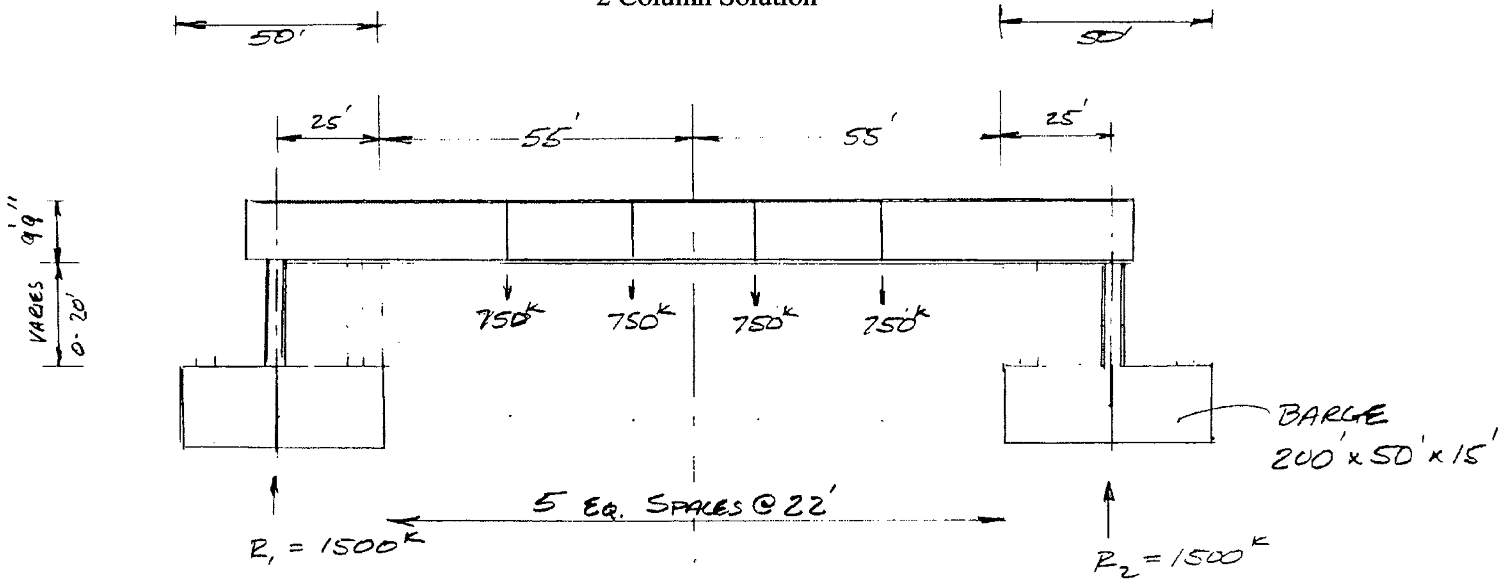
$$(+)\text{ Resisting Moments} = 55(2{,}365.4) = (+)\,130{,}097^{K1}$$

$$\text{Moment @ Midspan} = (+)\,26{,}626^{K1}$$

$$\text{Moment @ Support} = -28{,}472^{K1} \quad \text{(Controls)}$$

1" = 30'

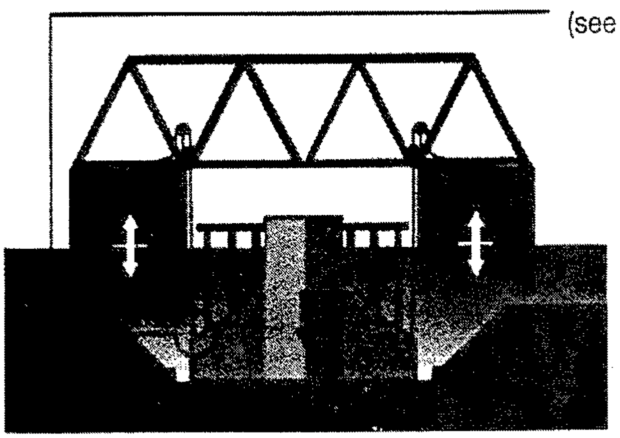
2 Column Solution



M_{MAX} (25 + 55) (1,500) – 750 (11 + 33) = 87,000[K1]

MOMENT/GIRDER = $\frac{87,000}{2}$ = 43,500[K1]

Appendix F
Technical Data and Cost Estimates on Catamaran Crane Barges with Linear Jacks



Lowering operation: schematical section

Estimate for 3,000 ton Capacity Catamaran (Linear Jack Method)

	Quantity			Unit Price		Extension
Basic Barge and Heavy Lift Beam System						
Purchase first work barge, 200 x 50 barge (Used)	10,000	sf	at	70	$/sf	$ 700,000
Purchase second work barge, 200 x 50 barge (Used)	10,000	sf	at	70	$/sf	$ 700,000
Rework Barges to accommodate 4 steel trussess	4	ea	at	75,000	$/each	$ 300,000
Rework Barges to accommodate 8 linear jacks	8	ea	at	100,000	$/each	$ 800,000
Purchase and Install 250 ton sponsons at outer column	4	ea	at	25,000	$/each	$ 100,000
Fab. Struct. Steel Trusses, 4 ea x 210' long x 0.80 k/lf	660,000	lbs	at	2.000	$/lb	$ 1,320,000
Fab. Hydraulic Cylinder lifting platforms, 8 ea x 60 k/ea	480,000	lbs	at	1.500	$/lb	$ 720,000
Erect Trusses and Platforms on barges	1,140,000	lbs	at	0.250	$/lb	$ 285,000
Fabricate Lateral Bracing to connect Catamarans	1	LS	at	50,000		$ 50,000
Install lateral bracing system	1	LS	at	25,000		$ 25,000
Fabricate Lifting Frame (attaches to structural shell)	700,000	lbs	at	1.500	$/lb	$ 1,050,000
Fabricate Survey Towers, 2 each x 50' high	40,000	lbs	at	1.250	$/lb	$ 50,000
Lifting System						
Purchase 350 ton Lifting Jacks and related Equip.	8	ea	at	40,000	$/each	$ 320,000
Purchase related mounting plates, equipment	8	ea	at	5,000	$/each	$ 40,000
Related Work						
Purchase and install electrical system	1	ea	at	550,000	$/each	$ 550,000
Purchase and install mechanical system	1	ea	at	390,000	$/each	$ 390,000
Cat Generator (150 kw)	2	ea	at	30,000	$/each	$ 60,000
Air Compressors	2	ea	at	10,000	$/each	$ 20,000
Engineering and Support Services	1	ea	at	350,000	$/each	$ 350,000
Mooring Equipment						
Skagit 3 Drum Winches	4	ea	at	100,000	$/each	$ 400,000
Danforth Anchors (15000 kg)	4	ea	at	30,000	$/each	$ 120,000
Misc. Anchors (7000 kg)	8	ea	at	20,000	$/each	$ 160,000
Hydraulic power packs and air tuggers	1	ls	at	50,000	$/each	$ 50,000
Install all winches, anchors, power systems	1	LS	at	200,000		$ 200,000
					Initial Construction Cost =	$ 8,760,000
					Less Salvage Value on Hulls	$ (700,000)
					Less Salvage Value on Mooring	$ (365,000)
					Total Cost, net of salvage	$ 7,695,000

Appendix F

Cost Analysis, 3,000 Ton Catamaran Barge with Linear Jacks (1 Year, 100% Usage)

Contract Time Period	1.0	years
Months of true operation	12.00	months per year
Cost of capital (interest rate)	8.0	percent
Sales Tax Rate	0.0	percent (tax included in construction cost estimate)
Salvage Value of Equipment	$ 1,065,000	(see detailed estimate for salvage value)

Cost to Manufacture Catamaran Barge Complete (see detailed estimate)		
Cost of Capital for duration of lift crane use	$ 700,800	(based on purchase cost of $ 8,760,000 for all equipment)
Depreciation Expense	$ 7,695,000	
Equipment Ownership Cost =	*$ 8,395,800*	

Cost to Mobilize and De-Mobilize Crane Once		
Cost to deliver barge #1 to site	$ 75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Cost to deliver barge #1 from site	$ 75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Cost to deliver barge #2 to site	$ 75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Cost to deliver barge #2 from site	$ 75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Assemble and Dis-assemble components	$ 137,500	(15 shifts @ $7,500/shift. Add $25K general expenses)
Mobilization/Demob Cost =	*$ 437,500*	

Cost to Operate Cranes				
Operators	4 each x	7,680 hrs =	$ 322,560	(Avg hrly labor cost is $42/hour)
Oilers	2 each x	3,840 hrs =	$ 122,880	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	6 each x	11,520 hrs =	$ 368,640	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1 each x	1,920 hrs =	$ 67,200	($15/hr FOG plus $20/hour in parts and mechanic for each barge)
Total Operating Cost =			*$ 881,280*	

Equipment Rental Cost =	$ 8,395,800
Mobilization & De-mobilization =	$ 437,500
Operating Costs =	$ 881,280
Total Crane Costs =	**$ 9,714,580**

Appendix F

Cost Analysis, 3,000 Ton Catamaran Barge with Linear Jacks (2 Year, 50% Usage)

Contract Time Period		2.0	years
Months of true operation		6.00	months per year
Cost of capital (interest rate)		8.0	percent
Sales Tax Rate		0.0	percent (tax included in construction cost estimate)
Salvage Value of Equipment	$	1,065,000	(see detailed estimate for salvage value)

Cost to Manufacture Catamaran Barge Complete (see detailed estimate)			
Cost of Capital for duration of lift crane use	$	1,457,664	(based on purchase cost of $ 8,760,000 for all equipment)
Depreciation Expense	$	7,695,000	
Equipment Ownership Cost =	*$*	*9,152,664*	

Cost to Mobilize and De-Mobilize Crane Once			
Cost to deliver barge #1 to site	$	75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Cost to deliver barge #1 from site	$	75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Cost to deliver barge #2 to site	$	75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Cost to deliver barge #2 from site	$	75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Assemble and Dis-assemble components	$	137,500	(15 shifts @ $7,500/shift. Add $25K general expenses)
Mobilization/Demob Cost =	*$*	*437,500*	

Cost to Operate Cranes							
Operators	4	each x	7,680	hrs =	$	322,560	(Avg hrly labor cost is $42/hour)
Oilers	2	each x	3,840	hrs =	$	122,880	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	6	each x	11,520	hrs =	$	368,640	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1	each x	1,920	hrs =	$	67,200	($15/hr FOG plus $20/hour in parts and mechanic for each barge)
Total Operating Cost =					*$*	*881,280*	

Equipment Rental Cost =	$	9,152,664
Mobilization & De-mobilization =	$	437,500
Operating Costs =	$	881,280
Total Crane Costs =	$	10,471,444

Appendix F

Cost Analysis, 3,000 Ton Catamaran Barge with Linear Jacks (3 Year, 50% Usage)

Contract Time Period		3.0	years
Months of true operation		6.00	months per year
Cost of capital (interest rate)		8.0	percent
Sales Tax Rate		0.0	percent (tax included in construction cost estimate)
Salvage Value of Equipment	$	1,065,000	(see detailed estimate for salvage value)

Cost to Manufacture Catamaran Barge Complete (see detailed estimate)

Cost of Capital for duration of lift crane use	$	2,275,077	(based on purchase cost of $ 8,760,000 for all equipment)
Depreciation Expense	$	7,695,000	
Equipment Ownership Cost =	*$*	*9,970,077*	

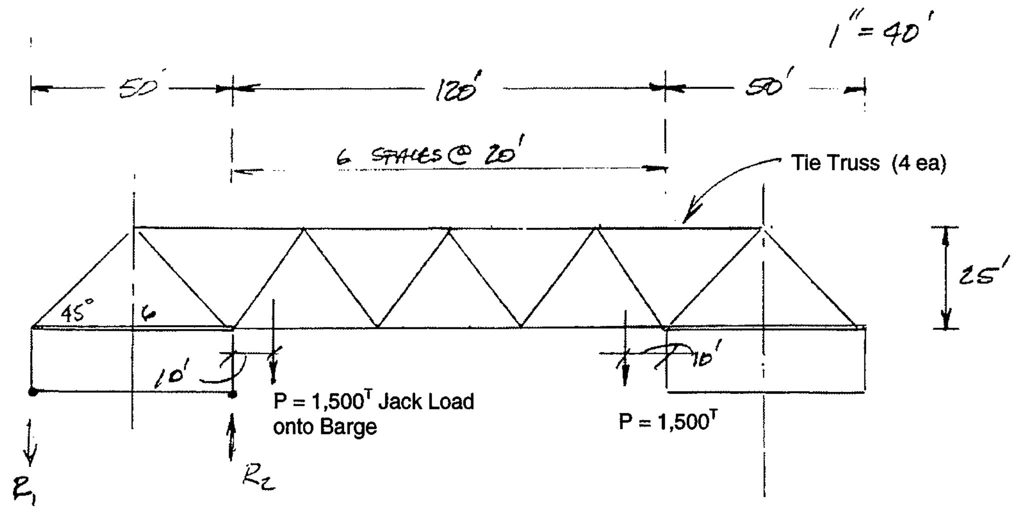
Cost to Mobilize and De-Mobilize Crane Once

Cost to deliver barge #1 to site	$	75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Cost to deliver barge #1 from site	$	75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Cost to deliver barge #2 to site	$	75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Cost to deliver barge #2 from site	$	75,000	(tug for 1 week at $10,000/shift, plus $25,000 general expenses)
Assemble and Dis-assemble components	$	137,500	(15 shifts @ $7,500/shift. Add $25K general expenses)
Mobilization/Demob Cost =	*$*	*437,500*	

Cost to Operate Cranes

Operators	4 each x	11,520 hrs =	$	483,840	(Avg hrly labor cost is $42/hour)
Oilers	2 each x	5,760 hrs =	$	184,320	(Avg hrly labor cost is $32/hour)
Deck Hands for crane	6 each x	17,280 hrs =	$	552,960	(Avg hrly labor cost is $32/hour)
Fuel, oil, grease, repair, maint.	1 each x	2,880 hrs =	$	100,800	($15/hr FOG plus $20/hour in parts and mechanic for each barge)
Total Operating Cost =			*$*	*1,321,920*	

Equipment Rental Cost =	$	9,970,077
Mobilization & De-mobilization =	$	437,500
Operating Costs =	$	1,321,920
Total Crane Costs =	$	11,729,497



(1) Total Load = $3{,}000 \rightarrow 1{,}500$ tons per barge

(2) Load spread over 4 trusses as shown. Each truss carries 375 tons of hydraulic jack loads

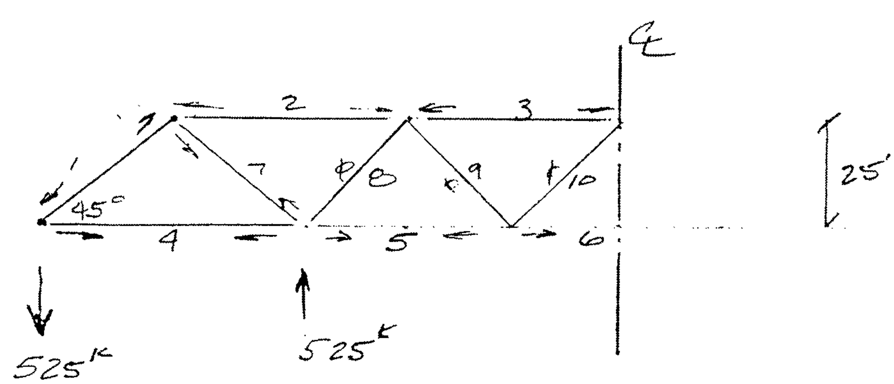
$$M = 375\left(\frac{50}{2} + 10\right) = 13{,}125^{\text{ton-ft}}$$

$$= 26{,}250^{\text{k-ft}}$$

$R_1 = -R_2 = T/C$ Couple

$$R_1 = \frac{26{,}250}{50} = 525^K$$

<u>Analyze Truss Loads</u>



Linear jack worksheet (Sheet 1 of 4)

Member 1 (Comp.)	$C = \sqrt{2} \cdot\ 525 = 742.5^K$
Member 4 (Ten.)	$T = \dfrac{742.5}{\sqrt{2}} = 525^K$
Member 2 (Comp.)	$C = \dfrac{50(525)}{25} = 1{,}050^K$
Member 7 (Ten.)	$T = \sqrt{2} \cdot\ 525 = 742.5^K$
Member 5 (Ten.)	$T = 2 \cdot\ 525 = 1{,}050^K$
Member 8 = 9 = 10	$T = C = 0$
Member 6 (Ten.)	$T = 1{,}050^K$
Member 3 = Member 2 =	$C = 1{,}050^K$
For this study allow	11 ksi Compression 20 ksi Tension

Member	Length (ft)	Load (kips)	Area Steel (in.)	Equiv. P^{LF}	Weight
1 (C)	35.4	743^k	68	232	8,300
2 (C)	35.0	$1{,}050^k$	96	326	11,410
3 (C)	40.0	1,050	96	326	13,000
4 (T)	50.0	525	27	92	4,600
5 (T)	40.0	1,050	53	180	7,200
6 (T)	20.0	1,050	53	180	3,600
7 (T)	35.4	743^k	38	130	4,600
8 (C)	32.0	300	27	92	3,000
9 (C)	32.0	300	27	92	3,000
10 (C)	32.0	300	27	92	3,000
					61,710

Linear jack worksheet (Sheet 2 of 4)

Total Truss Steel Estimate:

1/2 Truss Weights ~ 65,000 lb

Each Truss ~ 130,000 lb

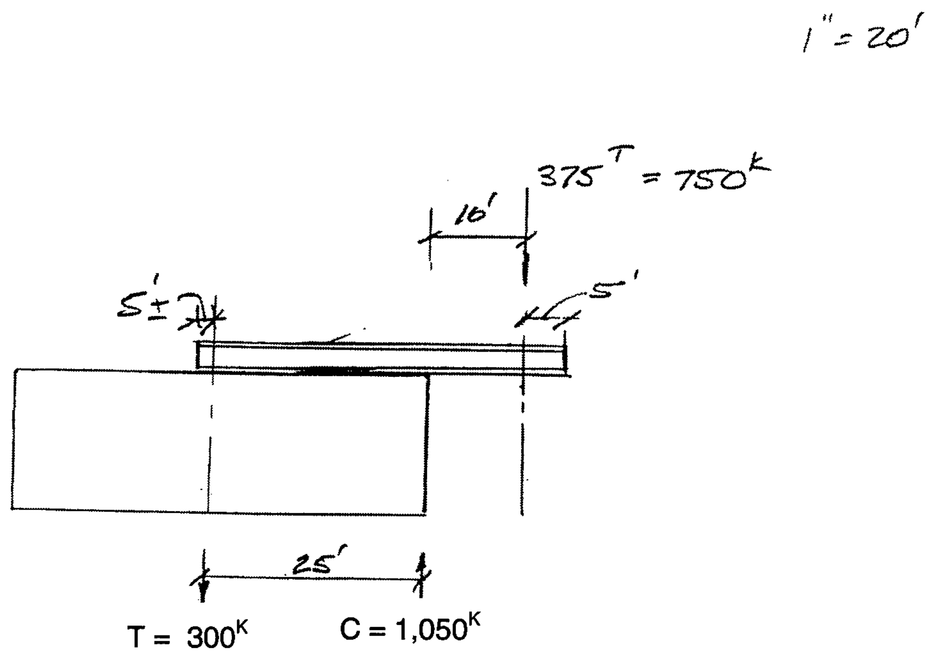
Total Weight = 130,000 × 4 = 520,000 lb

Add 25% for Lateral Bracing

Total Steel ~ 1.25 (520,000) = 650,000 lb

Linear jack worksheet (Sheet 3 of 4)

Check Lifting Platform



$$T = \frac{750 \times 10}{25} = 300^{K} \qquad C = 300 + 750 = 1{,}050^{K}$$

$$M_{MAX} = 10 \times 750 = 7{,}500^{K1}$$

$$S_R = \frac{7{,}500 \times 12}{21.6} = 4{,}166 \text{ in.}^3$$ [use 4 each W36 × 300 @ each jack]

K1 = 45 × 300 ≅ 15,000 lb/beam × 4 = 60,000 lb steel @ each jack point

This is conservative.

Linear jack worksheet (Sheet 4 of 4)

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14. ABSTRACT

This report examines the basic requirements, advantages, and limitations of floating crane equipment used to lift and position large (up to 500-ton) prefabricated concrete elements for constructing inland locks and dams. The first part of the report provides background information on use of the float-in and lift-in construction methods. Chapter 2 describes basic requirements and evaluation criteria for heavy-lift equipment used for transporting and installing large prefabricated modules in the U.S. inland waterways.

Chapter 3 summarizes an investigation of the eight general categories of heavy-lift equipment: lattice-boom crane (ringer- or pedestal-mounted) on floating barges, shear-leg ("A-frame"-type) crane barge, offshore crane barge, jack-up crane barge, catamaran barge with lifting beams, catamaran barge with linear jacks, float-over construction equipment, and synchronized multiple lifting systems. Each equipment type is evaluated with regard to cost, production rate, and suitability and availability for inland waterway construction.

The critical features of each equipment type (lift capacity, availability, mobility and productivity, and economics) are discussed in Chapter 4 and summarized in Table 5. Appendixes A-F provide detailed technical data and cost estimates for heavy-lift equipment types.

15. SUBJECT TERMS

A-frame crane barge	Jack-up crane barge	Revolving derrick
Catamaran barge	Lattice boom	Shear-leg crane barge
Floating crane	Lift-in construction	
Heavy-lift equipment	Offshore crane barge	

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